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WAVE CLIMATE STUDY NORTHERN COAST OF BRITISH COLUMBIA

by

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SUMMARY

This report describes a wave data collection program in northern British Columbia from July 1984 to March 1985. The objective of the program was to extend the existing data base for estimating the spatial and interannual variability in the wave climate as well as to provide information on the wave climate during the months when data were missing during the previous program.

Five instrument systems were operated over the nine-month period as follows:

MEDS STATION	LOCATION	INSTRUMENTATION
211	Langara West (Dixon Entrance)	Directional Wave Buoy (WAVEC)
213	Bonilla Island (northeast Hecate Strait)	Directional Wave Buoy (ENDECO) later replaced by non-directional buoy (Waverider)
215	Hecate Strait	Non-directional wave buoy (Waverider/WRIPS)
216	Queen Charlotte Sound	Non-directional wave buoy (Waverider/WRIPS)
	McKenny Island	Satellite-transmitting meteorology station

Minimal operational problems were experienced and data recovery rates were high. Both WRIPS buoys (Stations 215 and 216) and the weather station performed well during the program with average data recovery from the WRIPS greater than 99% and from the weather station greater than 87%. The data recovery from the WAVEC buoy (Station 211) was similarly high (>80%), including a one-month period when the flotation collar on the buoy failed. The ENDECO directional wave buoy experienced considerable electronic problems and no useful data were collected from this instrument (July to November 1984). The ENDECO buoy was replaced by a standard Datawell Waverider which operated well (data recovery 100%), except for a two-week period when the buoy was adrift.

The observed wave climate showed trends similar to those recorded during the previous program. The wave climate shows a strong seasonal variability with a relatively quiescent summer period (June to September) with low waves (H_S <2 m) and a storm period (October to March) of significantly higher waves. The transition period between "summer" and "winter" is very abrupt with October being one of the stormiest months of the year.

The most severe conditions were observed in Queen Charlotte Sound in November. There was considerable reduction of wave energy from Queen Charlotte Sound to Bonilla Island. In Dixon Entrance, the most energetic waves were from the west, as expected, while sea states from inshore directions had consistently lower peak periods. The directions of waves and winds recorded at the Langara Island lighthouse were not in phase, indicating that the winds from shore station are not representative of over-the-water winds.

Summary statistics include:

- the largest significant wave height in the study area (11.3 m) was observed in November in Queen Charlotte Sound;
- the largest zero-crossing wave height (17.5 m) was observed in December, also in Queen Charlotte Sound;
- during major storms, the most severe wave conditions consistently occurred in Queen Charlotte Sound;
- the monthly averages of significant wave height and of maximum wave height at the Langara West Station were almost always greater than those of the other three stations;
- Queen Charlotte Sound and the Langara West Station experienced almost equal duration of storm conditions.

RESUMÉ

Le présent rapport traite d'un programme de collecte de données sur les vagues qui a été réalisé en Colombie-Britannique de juillet 1984 à mars 1985. Le programme avait pour objectif d'élargir la base de données déjà établie afin d'estimer la variabilité spatiale et interannuelle du régime des vagues et d'obtenir des informations sur le régime des vagues pour les mois pendant lesquels aucune donnée n'avait pu être obtenue au cours de la réalisation du programme précédent.

Cinq groupes d'instruments ont été utilisés au cours d'une période de neuf mois:

Stations du SDMM	Endroits	Instruments
211	Langara West (Entrée Dixon)	Bouée houlographe directionnelle (WAVEC)
213	Ile Bonilla (nord-est du détroit d'Hécate)	Bouée houlographe directionnelle (ENDECO) ensuite remplacée par une bouée non directionnelle
215	Détroit d'Hécate	Bouée houlographe non directionnelle (WRIPS)
216	Détroit de la Reine-Charlotte	Bouée houlographe non directionnelle (WRIPS)
	Ile McKenny	Station météo à données transmises par satellite

Les problèmes d'exploitation ont été peu nombreux et les taux de collecte de données ont été élevés. Les bouées WRIPS (Stations 215 et 216) et la station météo ont bien fonctionné tout au long du programme; les taux d'obtention moyens de données ont excédé 99 % avec les bouées WRIPS et 87 % avec la station météo. Celui de la bouée WAVEC (Station 211) a aussi été élevé, plus de 80 %, même si durant une période d'un mois l'anneau de flottaison de la bouée n'a pas fonctionné. Les composantes électroniques de la bouée houlographe directionnelle ENDECO ont très mal fonctionné et aucune donnée utile n'a pu être obtenue (juillet à novembre 1984). Cette bouée a été remplacée par un houlographe Datawell standard qui a très bien fonctionné (taux de collecte de 100 %), si l'on fait exception d'une période de deux semaines où la bouée était à la dérive.

RESUMÉ (Cont'd)

L'allure du régime des vagues était semblable à celle notée au cours du programme précédent. Il présente une forte variabilité saisonnière. On note une période estivale (de juin à septembre) relativement calme avec des hauteurs de vagues peu élevées (Hs ` 2 m) et une période de tempêtes (d'octobre à mars) où les vagues sont beaucoup plus hautes. La transition entre "l'été" et "l'hiver" est très abrupte, les pires conditions de l'année étant observées en octobre.

Dans le détroit de la Reine-Charlotte les pires conditions ont été notées en novembre. L'énergie des vagues était considérablement réduite entre le détroit de la Reine-Charlotte et l'île Bonilla. Dans l'entrée Dixon, les vagues d'énergie plus élevée provenaient de l'ouest, comme prévu, et l'état de la mer, en direction côtière, présentait couramment des périodes de pics moins importants. Les directions des vagues et des vents enregistrées au phare de l'île Langara étaient déphasées, ce qui montre que les vents notés à la station riveraine ne sont pas représentatifs de ceux du large.

On compte parmi les données statistiques les plus significatives:

- La hauteur significative de vagues la plus élevée notée dans la région étudiée (11,3 m) l'a été en novembre dans le détroit de la Reine-Charlotte.

- La hauteur de vagues entre deux zéros la plus grande (17,5 m) a été notée en décembre, aussi dans le détroit de la Reine-Charlotte.

- Au cours des tempêtes importantes, les pires conditions de vague étaient pratiquement toujours notées dans le détroit de la Reine-Charlotte.

- Les moyennes mensuelles et les maximums des hauteurs significatives des vagues obtenues à la station de Langara West ont toujours été supérieurs aux conditions notées aux trois autres stations.

- Les durées des conditions de tempête ont pratiquement été les mêmes à la station du détroit de la Reine-Charlotte qu'à celles de Langara West.

INTRODUCTION

AREA DESCRIPTION

The coastal waters of northern British Columbia, which include Queen Charlotte Sound, Hecate Strait and Dixon Entrance, are one of the most productive fisheries regions in Canada (Figure 1). This part of the continental shelf contains shallow areas deeply cut by glacial troughs, and coastlines indented by many fjords. The general weather pattern for the area is characterized by strong south to southeast winds in winter changing to weaker westerlies or calm in summer. The increased marine activities related to fishing, recreation and export, and the potential for oil and gas exploration, have generated the need for a detailed understanding of the physical oceanographic environment of this region.

WAVE DATA

Until 1982, very few wave climate data had been collected in British Columbia waters. An initial wave climate study in the waters of the northern British Columbia coast was conducted from the fall of 1982 to the spring of 1984 to establish a wave climate database, to evaluate new instrumentation and deployment techniques, to develop software for processing directional wave data, and to develop wind/wave hindcasting models for the area. That program was carried out under the direction of the Marine Environmental Data Service (MEDS) and included wave measurements from a total of seven locations and meteorological measurements from one location (Juszko et al., 1985). Data from those instruments were processed and then archived at MEDS in Ottawa, as well as being used for directional and non-directional wave analysis and interpretation.

The present wave climate study covers an extension of the initial study, over the period from June 1984 to March 1985, under support from Environmental Studies Revolving Fund (ESRF) with the following objectives:

1. to generate a longer database for waves and over-the-water winds;

2. to provide information for the periods when data were missing during the previous year;

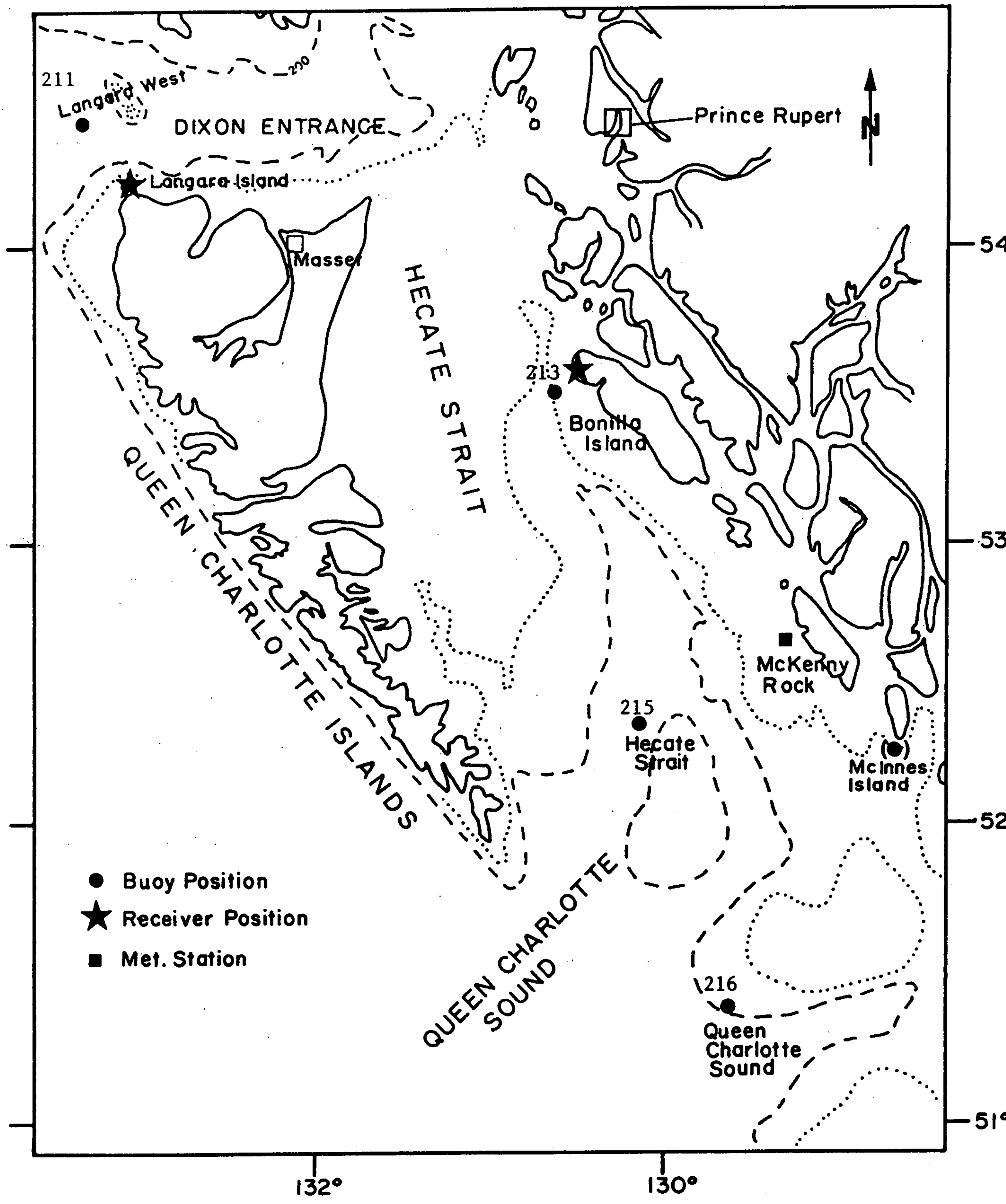


Figure 1. Locations of wave study buoys, receivers and meteorological station.

3. to provide an estimate of the interannual variability in the wave conditions.

This report describes the instrumentation used during the period May 1984 to March 1985, the field program, data analysis techniques, and the wave climate as observed by the buoys.

INSTRUMENTATION

PREVIOUS WAVE CLIMATE STUDY (1982-1984)

During the initial study, from the fall of 1982 to the spring of 1984, wave data were collected from six locations along the northern part of the British Columbia coast. The deployment locations were selected, based on the expected wave propagation characteristics in the area, and within 50 km of a manned shore station for buoys using VHF transmitters.

Wave data were obtained from:

- two standard Datawell Waverider buoys (stations 211, 212),
- one ENDECO Wave-Track Model. 956 system (station 213),
- one WAVEC Datawell directional buoy (station 214), and
- two WRIPS Waverider buoys (stations 215, 216).

Wind data were simultaneously collected using a satellite-transmitting meteorological station in a location with exposure to all wind directions (Juszko et al., 1985).

Locations for Stations 211, 213, 215 and 216 were selected to provide data on the behaviour of waves incident at Dixon Entrance and Queen Charlotte Sound, as well as those generated in the region. Station 212 was added to assess the effect of Learmouth Bank on the local wave climate and Station 214 to obtain wave characteristics in an area of possible focussing of wave energy.

WAVE CLIMATE STUDY EXTENSION (1984-1985)

During the extension of the data collection program to March 1985, the emphasis was on the overall wave climate of the region. Therefore, Stations 212 and 214 were discontinued. Furthermore, the Waverider buoy at Station 211 was replaced by a WAVEC system. At Station 213, an ENDECO Wavetrack system was deployed, but later replaced with a standard Waverider System. The other wave buoys and the meteorological station were serviced and re-deployed at their previous locations (Figure 1). The geographical coordinates, instrumentation and sampling description for each station are listed in Table 1.

TABLE 1

Summary of stations, instruments and sampling

A. Wave measurement systems

Station #	Station Name	Location	Water Depth	Instrument Type	Sampling Interval	Sample Description
211	Langara West	54°26.6' N 133°23.0' W	285 m	WAVEC Datawell's directional wave system	3 hours or Continuous if Hs > 4.5 m	20 minutes at .78215 second intervals, changed to 34 minutes on 20 Oct. 1984
213	Bonilla Island	53°19.3' N 130°43.0' W	159 m	ENDECO directional wave system, Wave-Track Model 956	3 hours	18 minutes at 0.5 second intervals.
				Datawell Waverider (replacement system)	3 hours or Continuous if Hs > 4.0 m	20 minutes of analog data
215	Hecate Strait	52°12.0' N 130°19.7' W	375 m	WRIPS Datawell's satellite buoy	3 hours	Based on 34 min. at 1 second intervals, spectral data at 35 frequencies.
					72 hours or Hs > 4.3 m	34 minutes of raw data at 1 sec. intervals.
216	Queen Charlotte Sound	51°18.2' N 129°58.3' W	262 m	WRIPS Datawell's satellite buoy	3 hours	Spectra at 35 frequencies.
					72 hours or Hs > 4.3 m	34 minutes of raw data at 1 sec. intervals.

TABLE 1. (Cont'd)

Summary of stations, instruments and sampling
B. Meteorological Station

Station Name	Position	Height Above Sea Level	Sensor	Sampling Interval	Sample Description
McKenny Island	52°39.1' N 129°28.3' W	19 metres	Met One speed sensors 1 and 2	1 hour	Ten minute averages
			Met One direction sensors 1 and 2	1 hour	Ten minute averages
			Met One temperature sensors 1 and 2	1 hour	Instantaneous
			YSI - Sostman barometric pressure transducer	1 hour	Instantaneous
			Wilh. Lambrecht GMBH Pernix humidity sensor	1 hour	Instantaneous

DATAWELL WAVEC SYSTEM

A WAVEC system manufactured by Datawell Inc. was deployed at Langara West (MEDS Station 211) to provide wave height and direction information through measurement of the buoy's vertical acceleration and determination of buoy slope induced by the waves. The system utilizes a Datawell Hippy-120 heave/pitch/roll sensor and a three-axis fluxgate compass mounted in a surface following buoy. Analog signals were transmitted continuously to the Langara Island Lighthouse, where they were processed and recorded.

Wave records from the Langara West station consist of approximately 34 minutes of data at 0.78125 second intervals, collected once every three hours. The data were recorded continuously whenever the wave record indicated that the estimated significant wave height exceeded 4.5 m.

ENDECO WAVE-TRACK SYSTEM

A Wave-Track Model 956 system manufactured by ENDECO was deployed off Bonilla Island (MEDS Station 213). This system utilizes an accelerometer, one two-axis fluxgate compass, and two tilt sensors consisting of small reservoirs of mercury with capacitance sensors which respond as inverted pendulums to any movement of the mercury induced by the shear in the wave orbital velocities.

The transmitted data were recorded at the Bonilla Island Lighthouse.

The Wave-Track system was set up to transmit and record data every three hours. The buoy experienced severe electronic problems which resulted in poor data recovery during the first few months of the program. Because of these problems, this buoy was eventually replaced with a Datawell Waverider buoy.

STANDARD DATAWELL WAVERIDER SYSTEM

The Datawell Waverider system (used to replace the ENDECO system at MEDS Station 213) utilizes an accelerometer mounted in a surface following buoy, the output of which is double-integrated to obtain the wave height time series. A continuous signal was transmitted to the Bonilla Island Lighthouse where it was processed and recorded for 20 minutes at three hour intervals. Wave data were recorded continuously whenever the significant wave height exceeded 4 m.

DATAWELL WAVERIDER INFORMATION PROCESSING SYSTEM (WRIPS)

The two WRIPS systems employed in this program were developed for the Datawell Waverider buoys by Adamo Rupp and Associates, for deployment in remote locations where normal radio transmission to a shore station is not possible. In these systems, the standard transmitter is replaced by a Data Collection Platform (DCP) and a satellite transmission system. The DCP digitizes the accelerometer output from the Datawell Hippy sensor, computes spectral estimates and outputs spectral data together with check parameters and selected summary statistics to the satellite transmission system and to an internal recorder. The DCP also outputs digitized raw data to the internal recorder along with the spectral information.

WRIPS systems were used at MEDS Station 216 in Queen Charlotte Sound and MEDS Station 215 in Hecate Strait since these were remote from any manned shore stations. The WRIPS buoys were set up to collect two wave records of 2048 samples each at 1 Hz sampling frequency, every three hours. The DCP is programmed to analyze every second wave record to generate spectral estimates within 35 frequency bands. These estimates, together with mean and maximum heave, variance, zero crossing period, buoy temperature, and check parameters for both wave records, were transmitted via GOES satellite to a computer at the National Environment Satellite Service (NESS) in Washington, D.C. These data were accessed by MEDS and transferred to the Dobrocky Seatech Ltd. computer via telephone modem. The buoy position was also transmitted via Service ARGOS to Maryland, where position data could be accessed by both MEDS and Dobrocky Seatech Ltd.

The DCP was also programmed to store the GOES message in the buoy on the internal recorder. The raw data were recorded internally every 72 hours or continuously whenever the significant wave height exceeded 4.3 m.

METEOROLOGICAL STATION

Over-the-water wind data were collected simultaneously with the wave data by a meteorological station placed on McKenny Island (Figure 1), and transmitted via satellite. This system was set up approximately 19 m above sea level and consisted of two sets of wind speed, direction and air temperature sensors manufactured by Met One Inc., one barometric sensor by YSI-Sostman and one Pernix humidity sensor built by Wilh. Lambrecht GMBH.

Hourly records consisting of ten minute averages of speed and direction data and instantaneous measurements of temperature, humidity and pressure were transmitted via GOES satellite and accessed by telephone modem for processing.

OVERVIEW OF DATA ACQUISITION

The field data acquisition component of the project commenced in June 1984 (Woodroffe, 1984a) and extended through March 1985. All instrumentation used during this period was provided by MEDS, except the meteorological station which was leased from and maintained by Petro-Canada Exploration Ltd. A summary of data recovery and cruises is presented in Figure 2 and Table 2, respectively.

During the ten months of deployment, the two WRIPS buoys collected, recorded and transmitted data without any problem (Table 2). However, the WAVEC buoy deployed at Langara West Station was damaged in January 1985; the dislocation of all four flotation segments caused large mean values for buoy tilts. A contingency cruise was carried out between February 27 and March 2 to recover, repair and re-deploy the buoy (Woodroffe, 1985).

The ENDECO system was serviced prior to field deployment by experienced electronic technicians from both Dobrocky Seatech Ltd. and MEDS, but this system experienced three major problems. First, the buoy timer board malfunctioned soon after the buoy was deployed resulting in data transmission at irregular intervals instead of every three hours. Second, the wave heights recorded at this site were found to have a non-uniform offset, probably caused by an accelerometer malfunction; at times, these offsets were unrealistically high (>6.0 m), and the wave amplitude output from the accelerometer was unrealistically low. Third, the wave records logged by the receiver system had very high noise levels making it difficult to decode the data. Subsequent analysis revealed that the data that were encoded, were very spikey. As a result of these problems, the ENDECO system was replaced by a Datawell Waverider on November 27, 1984 (Woodroffe, 1984b).

On January 2, the Waverider buoy deployed off Bonilla Island stopped transmitting data. A search and recovery attempt was delayed due to worsening weather conditions. When the weather improved, an aerial search was carried out using the Coast Guard helicopter, with no success. A replacement Waverider buoy was deployed on January 17 (McCullough, 1985). It is believed that the mooring line was severed as a result of (a) fishing activities in the area or (b) large floating rafts of kelp and deadheads.

The primary speed sensor and the secondary direction sensor of the McKenny Island meteorological station were damaged prior to the commencement of the 1984-85 program. Since at least one set of good data was available for each of the parameters, it was decided not to service this station during the deployment cruise; the system was however serviced during the November cruise (Woodroffe, 1984b). Problems were encountered

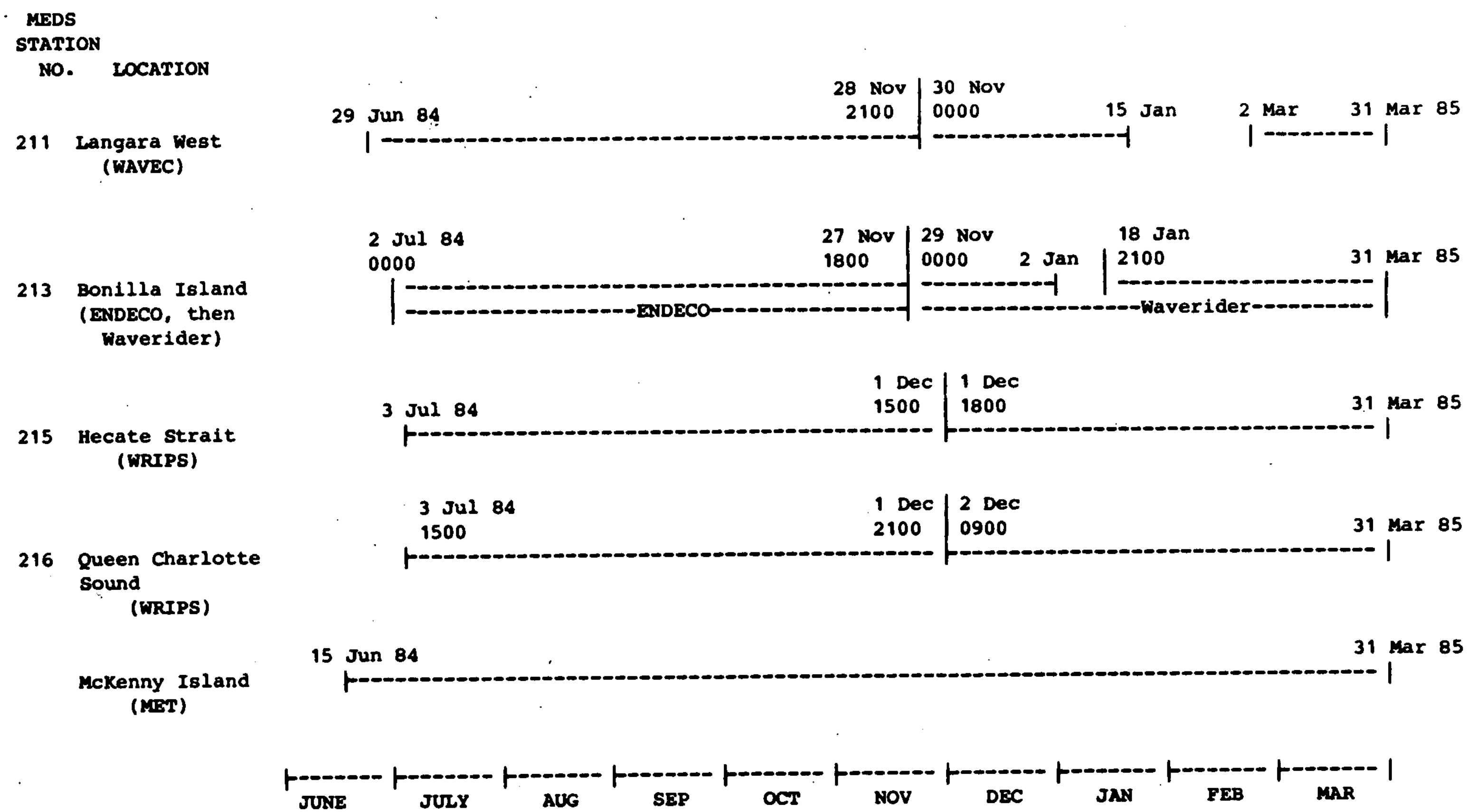


Figure 2. Data acquisition log.

TABLE 2

Cruise summary

Item	Period	Vessel	Personnel	Objective
Cruise No. 1 (Woodroffe, 1984a)	25 June to 4 July, 1984	MV ARRAWAC FREIGHTER	Dobrocky: D. Woodroffe B. Batstone MEDS: J. Murphy Captain: D. Hartley	Deploy all wave measurement systems
Cruise No. 2 (Woodroffe, 1984b)	26 November to 4 December, 1984	MV OCEAN ISLAND	Dobrocky: D. Woodroffe M. Hill Captain: C. Olafson	Service all systems; replace ENDECO with a Datawell Waverider
Cruise No. 3 (McCullough, 1985)	15 January to 18 January, 1985	MV OCEAN ISLAND	Dobrocky: D. McCullough S. Swift Captain: C. Olafson	Search for missing Waverider; deploy replacement Waverider at Bonilla Is.
Cruise No. 4 (Woodroffe, 1985)	27 February to 2 March, 1985	MV OCEAN ISLAND	Dobrocky: D. Woodroffe J. Harrington Captain: C. Olafson	Reinstall the flotation segments on WAVEC; redeploy

with the secondary direction sensor within a month after servicing, resulting in total data loss from this sensor. Since good data from other sensors were available, no further servicing cruises were scheduled.

Other gaps in the meteorological data were caused by problems with the computer or communication link to the GOES receiving station.

Although the data acquisition component of the study was completed on March 31, 1985, the wave measurement systems were not recovered until June 1985. The recovery of the instrumentation and redeployment were carried out by Dobrocky Seatech Ltd. under separate contract to MEDS.

DATA ANALYSIS

DATA TRANSFER

The annotated data cartridges from the Columbia tape recorder at Langara Island lighthouse, together with a copy of the field log, were collected by the Canadian Coast Guard during their bi-weekly visits and shipped to Dobrocky Seatech Ltd. where the tapes were transferred to the in-house PDP-11/34 computer system. A similar procedure was followed for the data from Bonilla Island Station during the ENDECO Wave-Track deployment period. When the Datawell Waverider with the analog recorder was set up at Bonilla Island, the tapes were shipped to Dobrocky Seatech Ltd. and then to MEDS, for transfer of these data to computer-compatible format.

The spectral data transmitted via GOES satellite were retrieved daily by MEDS using a telephone-computer link, and in turn accessed by the computer at Dobrocky Seatech Ltd. The buoys' position data were checked at regular intervals, and more frequently during storm conditions to ensure that the buoys had not broken loose from their moorings.

The GOES message and the raw data recorded internally were recovered during the servicing cruise and transferred to the PDP-11/34 computer using a Sea Data tape reader.

The McKenny meteorological data transmitted via GOES satellite were initially retrieved by Petro-Canada and later directly by Dobrocky Seatech Ltd. via a telephone modem link.

PRELIMINARY PROCESSING

The directional wave data transferred to the PDP-11/34 computer were checked for data gaps, calibrated and edited for obviously erroneous values resulting from electronic malfunction of the system (spikes). The criteria used for removing the spikes were as follows:

- a spike was defined as the minimum of either the maximum possible range of values or five times the standard deviation;
- spikes were interpolated over, but no more than seven consecutive spikes were allowed to be interpolated over;

- no more than 10% of a data block (1 block = 1 wave record for ENDECO and 256 samples for other Waveriders) could consist of interpolated values. If more than 10% of data in a block were edited, that block of data was removed from the file.

As part of the calibration process, the extremes and standard deviation were computed and listed for each wave record. Furthermore, as part of the quality control procedure, one record per week was plotted. These plots and listings were carefully examined for quality. The data were then analysed to provide wave spectra and stored in the Wave Climate Study Format.

Data from the WRIPS internal tapes were divided into two files, one containing the raw time series and the other containing the GOES message. The raw data time series were calibrated and edited using the criteria outlined above and stored in the Wave Climate Study format. The spectral data contained in the GOES message were checked, corrected for the transfer function of the buoy, and stored in the Wave Climate Study spectral format.

The data from Bonilla Island Station, were digitized by MEDS, then converted to SI units, edited and stored in the Wave Climate Study format. The time-series of data from both the internally recorded WRIPS stations and from the Bonilla Island Station were then analysed to compute wave spectra.

The meteorological data were transferred to the computer, decoded, checked for data gaps, and calibrated. The data were edited to remove obviously erroneous values, after which dew point temperatures (Td) were calculated from air temperature (Ta) and relative humidity (Rh).

The data gaps at each station were then identified. A monthly summary of data recovery is listed in Table 3.

SPECTRAL ANALYSIS

The calibrated edited heave data from the Datawell Waverider and the two WRIPS bouys were analysed using Fast Fourier Transform (FFT) techniques. For this purpose, each wave record was divided into blocks of 256 samples and transformed to the frequency domain after removing the mean value. The appropriate corrections were then applied to the spectral estimates using the instrument transfer function to compensate for the data filters within each system. Ensemble averages were computed using spectra truncated to be within 2 to 30 second wave periods. In the case of the WRIPS data, the wave spectra were also band-averaged to generate spectral estimates within 27 frequency bands as listed in Table 4.

TABLE 3

Monthly percentage of Station data recovery
(number of good records/expected number of records;
continuous records at non-standard times are not included)

	Wave Data				Meteorological Data
	Langara West	Bonilla Island	Hecate Strait	Queen Charlotte	McKenny Island
June, 1984	100				
July	98	0	100	100	77
August	96	0	100	100	63
September	98	0	100	100	94
October	98	0	100	100	83
November	95	100	100	99.5	92
December	90	100	100	100	97
January, 1985	48*	52**	100	100	90
February	0*	100	100	100	97
March	94	100	100	100	97

* buoy flotation damaged
** buoy lost; replaced

TABLE 4

Frequencies of spectral estimates transmitted by WRIPS

	Frequencies at Center of Band (Hz)	Number in band	Estimate Number
1	3.515625E-02	1	8
2	3.90625E-02	1	9
3	4.296875E-02	1	10
4	4.6875E-02	1	11
5	5.078125E-02	1	12
6	5.46875E-02	1	13
7	5.859375E-02	1	14
8	6.25E-02	1	15
9	6.640625E-02	1	16
10	7.03125E-02	1	17
11	7.421875E-02	1	18
12	7.8125E-02	1	19
13	8.203125E-02	1	20
14	8.59375E-02	1	21
15	8.984375E-02	1	22
16	9.375E-02	1	23
17	9.765625E-02	1	24
18	.101562	1	25
19	.105469	1	26
20	.109375	1	27
21	.119141	4	28-31
22	.134766	4	32-35
23	.154297	6	36-41
24	.183594	9	42-50
25	.226562	13	51-63
26	.292969	21	64-84
27	.417969	44	85-128

The directional wave data were spectrally analysed by Seaconsult Marine Research Ltd., to compute estimates over a range of frequencies corresponding to wave periods between 2 and 30 seconds. The principal wave direction and cosine spreading parameter were computed at each frequency using the algorithm given in Longuet-Higgins et al. (1963). The spectral estimates were then corrected using the manufacturer-supplied transfer function to compensate for the data filters within each system. It is important to note that the directional analysis used here cannot resolve a bimodal directional energy distribution for a given frequency. Accordingly, where there is wave energy from two or more directions at the same frequency, the principal wave direction resulting from the fitting of an even cosine power curve may not correspond to any one actual direction of wave energy propagation.

DATA PRODUCTS

Based on the calibrated, despiked wave records and the corresponding spectral files, time series of significant wave height, peak period, maximum zero up-crossing wave height, average period, peak energy direction, and spectral shape parameters were generated. The following data products were then plotted and supplied to MEDS in a hard copy form. The calibrated time series and spectral data were also supplied to MEDS on magnetic tapes.

1. Time series plots:
   - significant wave height, peak period, maximum wave height, and peak direction (for WAVEC only).

2. Histograms:
   - significant wave height vs. peak period, monthly;
   - significant wave height vs. peak direction, monthly (for WAVEC only);
   - peak direction vs. peak period, monthly.

3. Percent occurrence and exceedance plots:
   - significant wave height, monthly;
   - peak period, monthly;
   - peak direction, monthly (for WAVEC only).

4. Persistence tables:
   - persistence of significant wave height vs. wave height, monthly;
   - persistence of peak period vs. peak period, monthly;
   - persistence of peak direction vs. peak direction, monthly (for WAVEC only).

5. Tables of root mean square wave height vs. period.

6. Spectral plots corresponding to maximum significant wave height for major storms.

The calibrated meteorological data were similarly processed to generate:

1. Time series of wind velocity, air temperature, dew point temperature, and relative humidity.

2. Histogram of wind speed vs. direction, monthly.

3. Percent occurrence and exceedance plots of wind speed, monthly.

4. Percent occurrence plots of wind direction, monthly.

5. Persistence of speed vs. speed, monthly.

6. 16 point wind summary listings.

The wave heights are computed in metres and the times are in GMT. The directions of wind and waves are those from which they arrive, using angles in degrees clockwise from true north. The wind speeds in the plots and in the files are in m/sec but the 16 point wind summary tables give speeds in km/hr to conform with the meteorological format.

Examples of each of the data products and an explanation as to their content are included in Appendix A.

WAVE CLIMATE

OVERVIEW OF RESULTS

The wave climate at each station consists of swells propagating into the region from the Pacific Ocean, and seas generated locally. The frequency and size of the swells are dependent on the wave propagation route to the site from the open ocean whereas the sea characteristics are determined by the local wind strength, direction, and fetch. As a result, the wave climate is expected to differ considerably from site to site.

During the 1982-84 study, the most extreme wave conditions were observed at Queen Charlotte Sound Station during the winter season (Juszko et al., 1985). Langara West Station had the second highest mean significant wave heights although maximum significant wave heights at Langara West Station were generally lower than those in Hecate Strait. Unfortunately, during the previous program, poor data recovery at Bonilla Island Station made it difficult to compare the wave climate at this site with that of the other locations.

Time series of significant wave height and peak period along with wind time series from the nearest weather station, are included in Appendix C. Table 5 summarizes the wave statistics estimated over the 1984-85 study period; the wind statistics estimated from the McKenny Station are summarized in Table 6. For each station, the storm periods (H_s > 5 m), are listed in Tables 7, 8, 9 and 10, together with the corresponding wave statistics. From review of these tables, the following comments can be made:

- the largest H_s in the study area was observed in November in Queen Charlotte Sound (H_s = 11.3 m); the largest zero-crossing wave height was observed in December, also in Queen Charlotte Sound (H_{ZO} = 17.5 m);

- during major storms, the most severe wave conditions consistently occurred in Queen Charlotte Sound;

- the monthly averages of H_s and of the maximum wave height at the Langara West Station were almost always greater than those at the other three stations;

- Queen Charlotte Sound and the Langara West Station experienced almost equal duration of storm conditions.

The detailed characteristics of the wave climate in the study area may be readily deduced from the data products presented in the appendices. The McKenny Island meteorological data show that winds were generally weak

TABLE 5

Monthly mean and maximum of H_s and of the largest zero-crossing wave height (in brackets) estimated from each record (in metres)

	Langara West		Bonilla I.		Hecate St.		Queen Charlotte	
	Max.	Mean	Max.	Mean	Max.	Mean	Max.	Mean
July	3.8 (5.4)	1.3 (2.0)	No Data		2.4 (4.3)	0.7 (1.3)	2.6 (4.5)	1.2 (1.9)
Aug.	6.1 (11.6)	1.8 (2.7)	No Data		4.5 (7.7)	1.0 (1.7)	4.9 (8.3)	1.6 (2.5)
Sept.	4.4 (7.1)	2.0 (3.1)	No Data		3.7 (7.3)	1.2 (2.1)	3.6 (5.7)	1.9 (3.1)
Oct.	7.3 (13.7)	3.3 (5.1)	No Data		9.0 (13.5)	2.4 (4.0)	10.5 (16.5)	3.3 (5.3)
Nov.	9.4 (16.2)	3.8 (6.1)	3.1 (5.0)	1.9 (2.8)	8.3 (14.5)	2.7 (4.2)	11.3 (16.4)	3.7 (5.9)
Dec.	8.5 (14.5)	4.1 (6.3)	5.0 (7.9)	1.4 (2.2)	5.8 (10.2)	1.9 (3.0)	9.2 (17.5)	3.3 (5.3)
Jan.	6.6 (10.9)	4.1 (5.8)	3.8 (6.2)	1.4 (2.3)	7.7 (13.5)	2.9 (4.4)	8.1 (13.2)	3.5 (5.6)
Feb.	No Data		9.2 (15.7)	2.3 (3.6)	8.8 (14.7)	2.2 (3.5)	9.4 (15.2)	3.5 (5.5)
March	6.3 (10.4)	3.7 (5.9)	5.4 (8.5)	1.5 (2.5)	5.3 (8.5)	1.8 (2.8)	6.9 (10.8)	3.4 (5.4)

TABLE 6

Summary Wind Statistics

	No. of Observations	Maximum Windspeed (m/s)	Direction at Maximum Speed (O/T)	Percent occurrence of wind-speeds >15 m/s	No. of occurrences of calm
June	360	24	SE	7.5	1
July	572	13	SSE	0	29
August	469	15	SE	0.2	5
September	675	25	SSE	5.5	5
October	618	31	SE	22.6	9
November	659	31	SE	13.5	6
December	718	26	SSE	8.9	3
January	672	26	SSE	15.0	10
February	649	31	SSE	18.0	7
March	722	23	SE	13.4	6

TABLE 7

Storm events at Langara West (H_s >5m)

Start Time	End Time	H_s (m) Max.	H_s (m) Mean	Direction at peak Energy	Peak Period(s) Max.	Peak Period(s) Mean	Peak Period(s) Min.	Max. Wave Ht (m)	Max. wind at McKenny (m/s)
27 Aug. '84 00:00	27 Aug. '84 18:00	6.1	5.5	280	14.1	13.5	11.6	11.6	14
5 Oct. '84 18:00	6 Oct. '84 00:00	5.5	5.3	200	11.6	10.9	10.6	8.1	21
7 Oct. '84 18:00	8 Oct. '84 04:13	6.3	6.0	208	14.1	12.4	9.9	10.6	25
9 Oct. '84 23:56	10 Oct. '84 12:01	6.2	5.6	196	14.1	12.0	8.6	11.0	31
25 Oct. '84 00:00	25 Oct. '84 18:26	7.3	6.2	250	14.1	12.4	10.7	13.7	14
1 Nov. '84 13:13	2 Nov. '84 00:10	6.2	5.7	92	12.9	9.8	8.1	10.6	17
19 Nov. '84 23.38	23 Nov. '84 18:00	9.4	6.6	226	17.8	13.5	9.2	16.2	31
10 Dec. '84 10:01	10 Dec. '84 15:00	5.3	5.2	272	14.1	14.1	14.1	9.6	8.3
12 Dec. '84 08:56	13 Dec. '84 09:14	8.5	6.9	272	18.0	14.9	12.7	14.1	26
14 Dec. '84 02:43	15 Dec. '84 09.00	7.7	6.2	274	14.3	13.4	10.6	14.5	14
2 Jan. '85 15:00	3 Jan. '85 00:35	5.4	5.2	211	117	10.9	10.7	9.4	14
11 Jan. '85 06:00	11 Jan. '85 12:35	6.5	5.9	198	14.1	12.0	10.7	9.6	26
15 Jan. '85 06:29	15 Jan. '85 18:09	6.6	6.1	224	14.1	12.1	10.7	11.2	19
4 Mar. '85 21:00	5 Mar. '85 02:09	5.7	5.4	284	14.1	13.2	11.6	10.4	14
15 Mar. '85 21:00	16 Mar. '85 12:00	5.6	5.4	254	15.8	12.1	11.58	9.9	18
18 Mar. '85 09:00	19 Mar. '85 00:14	6.3	5.4	270	15.8	13.9	12.8	9.7	16

TABLE 8

Storm events at Bonilla (H_s >5m)

Start Time	End Time	H_s (m)		Peak Period(s)			Max. Wave Ht (m)	Max. wind at McKenny (m/s)
		Max.	Mean	Max.	Mean	Min.		
11 Feb. '85 19:30	12 Feb. '85 01:50	9.2	7.4	13.6	11.7	7.56	15.7	31
14 Feb. '85 00:00	15 Feb. '85 00:00	8.4	6.9	13.6	12.3	10.5	12.9	30

TABLE 9

Storm events at Hecate Strait (H_s >5m)

Start Time	End Time	H_s (m) Max.	H_s (m) Mean	Peak Period(s) Max.	Peak Period(s) Mean	Peak Period(s) Min.	Max. Wave Ht (m)	Max. wind at McKenny (m/s)
5 Oct. '84 21:38	7 Oct. '84 06:38	6.6	5.6	10.7	9.8	9.1	11.3	24
10 Oct. '84 03:38	10 Oct. '84 15:38	5.6	5.2	12.2	10.7	9.8	10.3	31
12 Oct. '84 15:38	13 Oct. '84 15:38	9.0	7.6	16.0	13.1	10.2	13.5	31
1 Nov. '84 06:38	2 Nov. '84 09:38	8.3	6.3	12.2	10.9	9.1	14.5	17
17 Nov. '84 18:38	18 Nov. '84 00:38	6.8	6.6	11.1	10.5	9.8	12.0	18
22 Nov. '84 00:38	23 Nov. '84 03:38	8.3	6.7	12.2	10.7	9.5	14.2	31
27 Nov. '84 12:38	27 Nov. '84 21:38	8.0	6.7	14.2	13.7	13.5	11.2	14
6 Dec. '84 06:38	6 Dec. '84 18:38	5.8	5.5	10.7	10.1	9.8	10.2	26
11 Jan. '85 00:38	12 Jan. '85 09:38	7.7	6.4	12.8	10.6	9.1	13.5	26
16 Jan. '85 15:38	17 Jan. '85 00:38	5.7	5.3	12.2	10.9	9.5	9.3	25
12 Feb. '85 15:38	12 Feb. '85 09:38	8.1	6.3	12.8	11.2	9.8	14.7	31
14 Feb. '85 03:38	15 Feb. '85 15:38	8.8	6.9	13.5	12.3	11.1	13.0	30

TABLE 10

Storm events at Queen Charlotte Sound (H_s >5m)

Start Time	End Time	H_s (m) Max.	H_s (m) Mean	Peak Period(s) Max.	Peak Period(s) Mean	Peak Period(s) Min.	Max. Wave Ht (m)	Max. wind at McKenny (m/s)
5 Oct. '84 18:39	7 Oct. '84 09:39	7.2	5.9	10.2	9.8	8.4	11.8	24
10 Oct. '84 00:39	11 Oct. '84 00:39	6.7	5.8	13.5	12.3	11.1	10.0	31
12 Oct. '84 12:39	13 Oct. '84 18:39	10.5	9.6	15.1	13.3	9.5	16.5	31
1 Nov. '84 09:39	2 Nov. '84 18:39	11.3	6.8	13.5	11.3	9.1	16.4	17
17 Nov. '84 12:39	18 Nov. '84 00:39	6.8	6.1	11.1	10.8	10.2	13.7	18
20 Nov. '84 03:39	20 Nov. '84 12:39	5.7	5.5	18.3	16.4	14.2	9.7	12
22 Nov. '84 03:39	23 Nov. '84 12:39	7.8	6.7	14.2	11.5	9.5	12.5	31
27 Nov. '84 03:39	28 Nov. '84 00:39	9.0	6.8	13.5	12.0	9.1	14.3	14
6 Dec. '84 09:39	6 Dec. '84 18:39	5.7	5.6	10.7	9.7	9.1	9.0	26
12 Dec. '84 15:39	13 Dec. '84 15:39	9.2	7.2	18.3	15.2	11.6	17.5	26
14 Dec. '84 12:39	15 Dec. '84 12:39	8.0	6.6	14.2	13.1	11.6	12.3	14
11 Jan. '85 03:39	12 Jan. '85 09:39	8.1	6.6	12.2	10.1	9.1	13.2	26
16 Jan. '85 15:39	17 Jan. '85 06:39	5.9	5.6	14.2	11.5	9.1	10.0	25
11 Feb. '85 12:39	12 Feb. '85 18:39	9.4	6.8	12.2	10.9	9.1	15.2	31
13 Feb. '85 21:39	15 Feb. '85 21:39	8.5	7.2	14.2	11.8	8.4	14.7	30
4 Mar. '85 06:39	4 Mar. '85 15:39	6.9	6.4	15.1	14.7	14.2	10.8	14

(<15 m/s) in July and August and were mostly from the southeast. Maximum wind speeds of 31 m/s were observed in October, November and February, coinciding with severe sea states evident in the wave data. October had the largest percentage occurrence of wind speeds greater than 15 m/s followed by February and January.

Previous measurements (Juszko et al., 1985) indicated that the wind data recorded at Bonilla Island Station and McKenny Island Station were comparable, when allowing for the differences in sampling interval and resolution in direction. However, considerable differences were noticeable between McKenny Island winds, and winds at Langara Island and Cape St. James, as could be expected from the differences in local topography. It was also observed that the wind directions recorded at the Langara Island lighthouse differed significantly from the wave directions estimated from WAVEC data. This indicates that the lighthouse wind data may not be representative for over-the-water winds at the wave stations.

LANGARA WEST STATION

A summary time series plot of significant wave height is included as Figure 3. As indicated in the data products, low wave conditions prevailed at the Langara West Station during the months of July and September, and in August except for eighteen hours when H_s exceeded 5 m and reached a maximum value of 6.1 m. In contrast, from October to March (excluding the period from January 15 to February 28 when the WAVEC mooring was damaged) there were a total of fifteen events when H_s exceeded 5 m. As was expected the most energetic waves were predominantly from a west-southwesterly direction while sea states from inshore directions had consistently lower peak periods (Appendix C).

The largest H_s (9.4 m) and the largest zero-crossing wave height (16.2 m) were both observed in November, even though the maximum number of storm events were recorded in October. November was also the month when storm wave conditions prevailed for the maximum number of hours (101 hrs). Interestingly, the most severe wave conditions at the Langara West Station were not due to the storm which generated the largest significant wave height over the study area. In fact, during the storm which generated the largest H_s in Queen Charlotte Sound, the significant wave heights at Langara West Station were less than 6.4 m, which is indicative of the spatial variations in the wave climate. This is also evident in the March data when several storm events were recorded at the Langara West Station while Hecate Strait and Bonilla Island stations were storm-free. In March, Queen Charlotte Sound had the largest H_s over the study area even though the number of hours when H_s exceeded 5 m were less here than at Langara West Station.

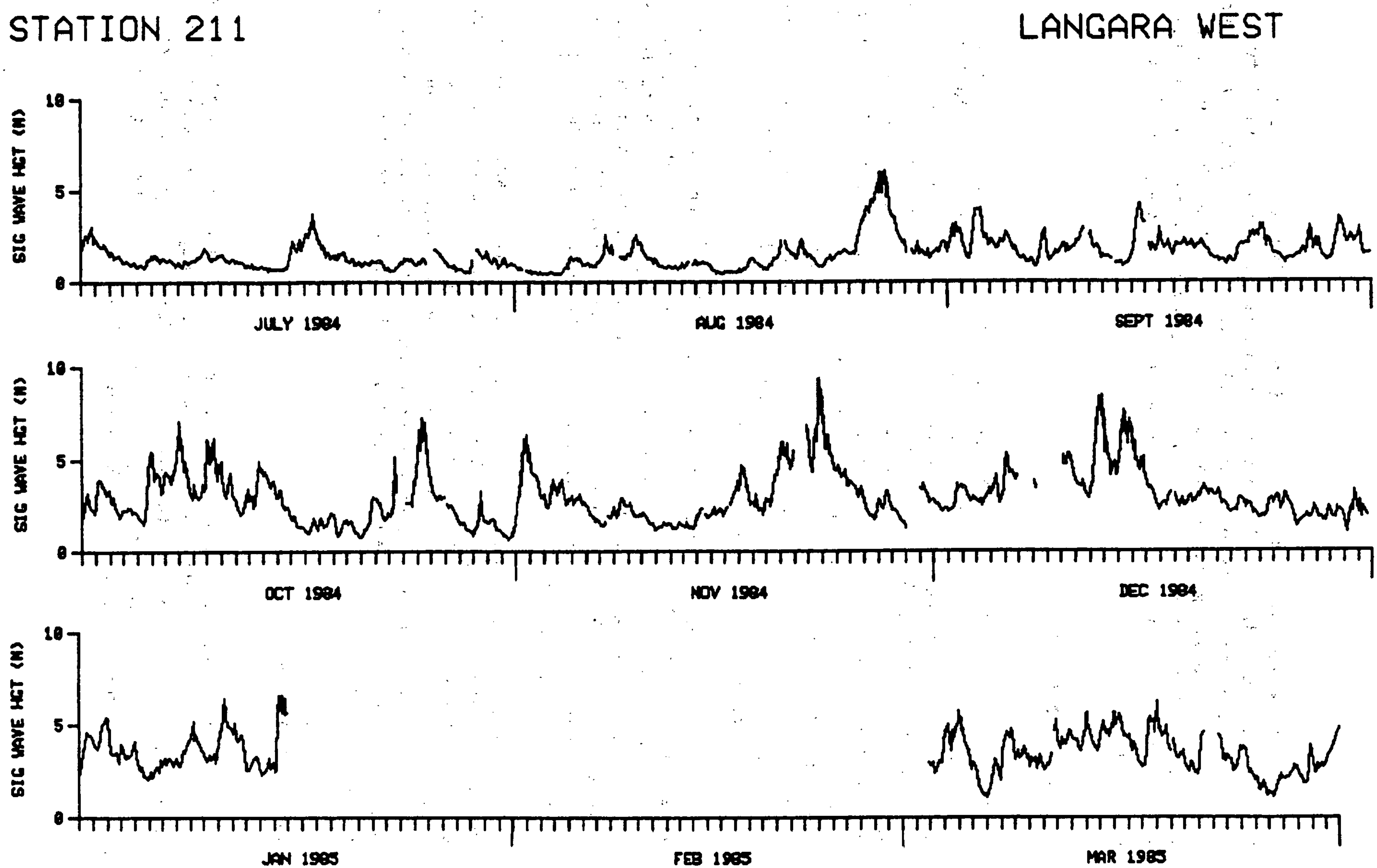


Figure 3. Time series of significant wave height for the study period.

The time series plots of the winds recorded at the Langara Island lighthouse (Appendix C) indicated considerable differences between the wind and wave directions even when peak energy was at short wave periods (i.e., for locally generated waves). This indicates that the lighthouse winds may not be representative for over-the-water winds. An example of a wave direction variation as a function of frequency is indicated in Figure 4.

BONILLA ISLAND STATION

The complete lack of data recovery from the ENDECO buoy makes it impossible to deduce the wave climate during the summer and fall seasons. However, from November 27 to March 31 with the exception of the period from January 2 to 17, wave data were recorded at the Bonilla Island Station using a standard Waverider (Figure 5). Based on these data, it may be deduced that the wave climate at the Bonilla Island Station was in general less severe than that at the other measurement sites (Table 5). The estimated values of H_s were less than or equal to 5 m in November, December and January even though H_s reached 8 m in Hecate Strait during these months. Low wave conditions prevailed in March, when all estimated H_s were less than 5 m except for one record.

The monthly maximum wave height (15.7 m) and the largest H_s (9.2 m) were both recorded in February (Table 8; Figure 5). Interestingly, during this storm both H_s and the maximum wave height at the Bonilla Island Station were larger than those at the Hecate Strait station and were comparable to those recorded at the Queen Charlotte Sound station. Unfortunately no data were available for comparison from the Langara West Station during this storm.

Wave heights show only a weak correlation with measured wind speed at Bonilla Island (Appendix C). Although the two major storm-wave events are correlated with strong southeast winds (> 75 km/hour), there are numerous other high wind events, including some from the southeast quadrant, that have no corresponding high wave conditions. As such, the local wind data alone does not appear adequate, at first glance, to characterize the wave generating area.

HECATE STRAIT STATION

As expected, low wave conditions were found to prevail in Hecate Strait during the months of July, August and September (Figure 6); wave conditions were also mild in March. Even during the period in August when H_s exceeded 5 m at the Langara West Station, the significant wave heights in Hecate Strait were less than 4.5 m.

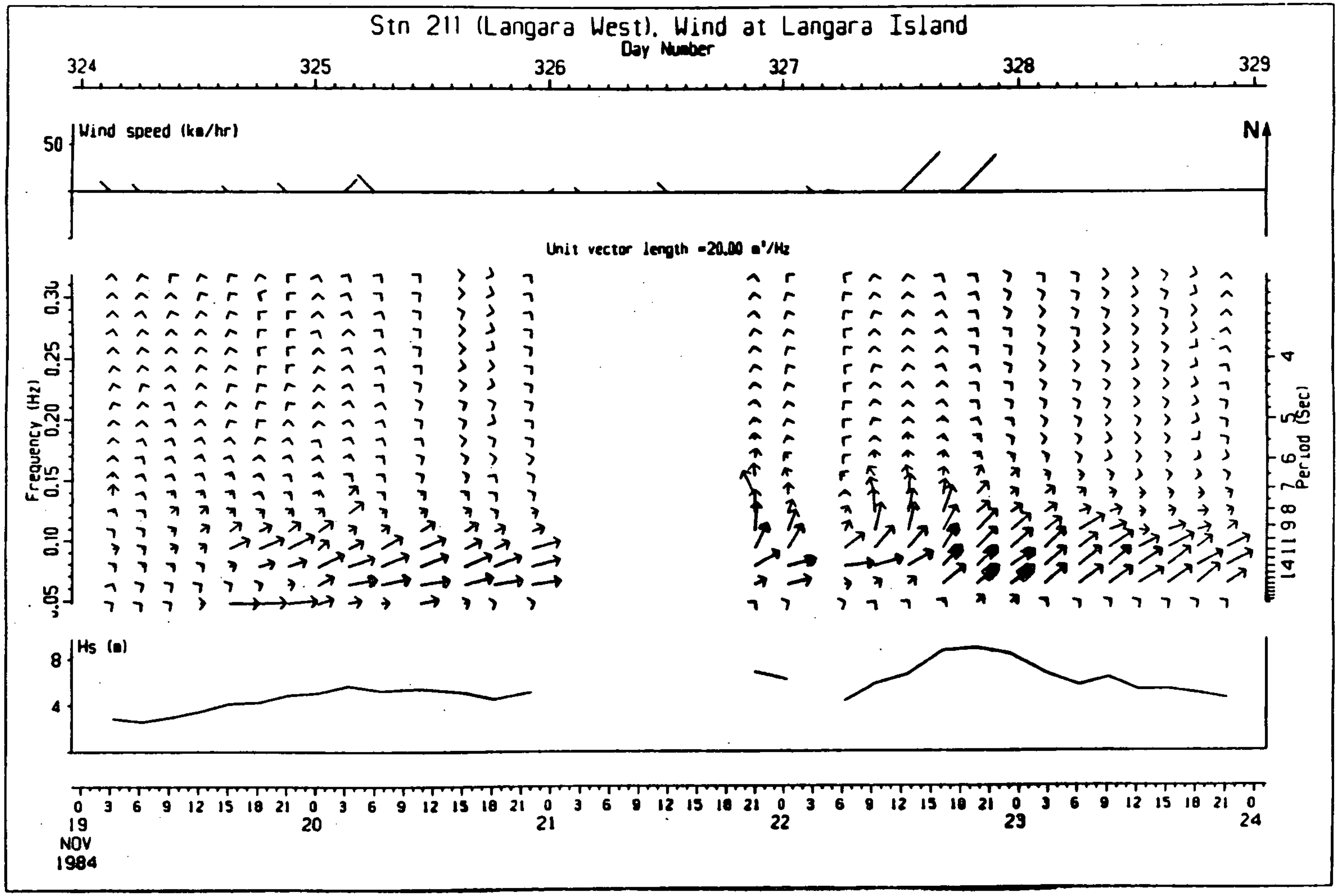


Figure 4. Wind speed and direction, frequency dependent wave direction and significant wave height for the 23 November storm at Langara West (produced by Seaconsult Marine Research Ltd.).

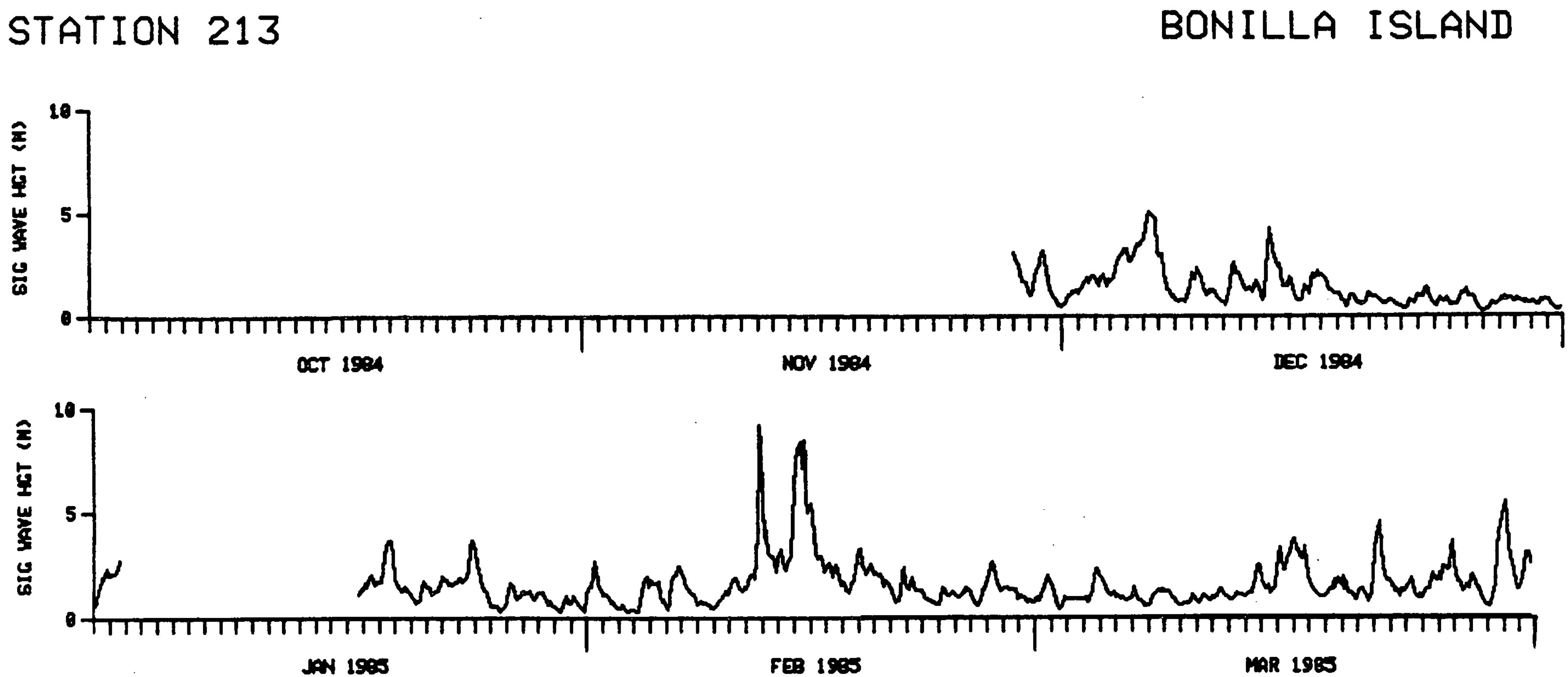


Figure 5. Time series of significant wave height during the study period at the Bonilla Island station.

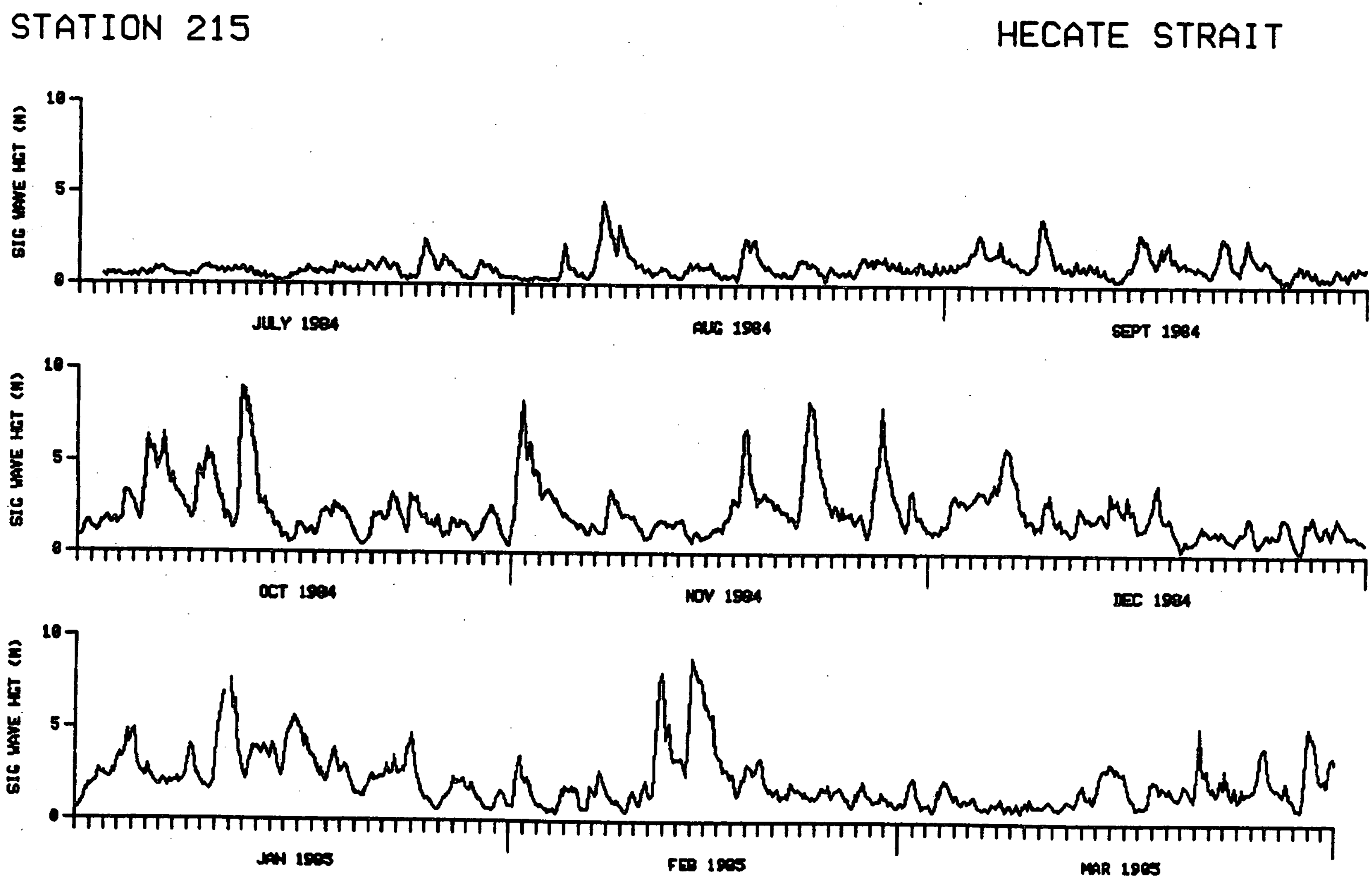


Figure 6. Time series of significant wave height during the study period at the Hecate Strait station.

Several storm events were recorded from October to February (Table 9; Figure 6). It can be seen that the maximum H_s recorded during each storm ranged from 5.6 m to 9.0 m while the maximum wave heights ranged from 9.3 m to 14.7 m. The highest value of H_s was obtained during the October 12 storm while the largest zero-crossing wave height was recorded in February. Even though at least one storm event was recorded in each month from October to February, the month of December was comparatively storm-free except for a weak storm which lasted for 12 hours on December 6 when H_s reached a peak value of 5.8 m. The fact that the Queen Charlotte Sound station experienced several storms in December with H_s reaching a peak value of 9.2 m, indicates that swells decay considerably while propagating from Queen Charlotte Sound to Hecate Strait. This fact is also evident in the percent occurrence tables for the two WRIPS stations. However, it should be noted that the WRIPS buoys were not designed to record data in a continuous mode during storms as was the case with WAVEC and Waverider buoys. No direct comparison can be made of percent occurrences and exceedences of wave parameters estimated from WRIPS data with those recorded at the Langara West or Bonilla Island stations.

Comparative time-series plots of wind speed and direction at Cape St. James and significant wave height at Hecate Strait are presented in Appendix C. Review of these plots indicates a reasonable correlation of strong wind events and large wave conditions (e.g., Appendix C, see Hecate Strait, November); the correlation is strongest as fronts pass through the area, with winds shifting from north through the southerly quadrant (i.e., southeast). Strong winds from the southwest sector did not cause appreciable waves at the Hecate Strait station.

QUEEN CHARLOTTE SOUND STATION

The most extreme wave conditions were observed at the Queen Charlotte Sound station in winter. From October to February, a number of storm events were recorded with maximum H_s ranging from 5.7 m to 11.3 m (Table 10; Figure 7). During this period, this station experienced the largest H_s per month; the number of hours when H_s exceeded 5 m in each month was also the largest at this location, except in December when Langara West Station recorded the longest duration of storm-wave occurrences. November was the month when the most severe wave conditions prevailed in Queen Charlotte Sound. The maximum number of storm events and maximum number of hours when H_s exceeded 5 m were both in November. The wave record with the largest significant wave height in the study area was logged in November at this station, followed by an interruption in the time-series (Figure 7). The maximum zero-crossing wave height of 17.5 m was recorded in December.

As was expected, low wave conditions prevailed from July to September 1984 when the significant wave heights were less than 5 m (Figure 7). There were also no storm events during March, except for a nine hour period

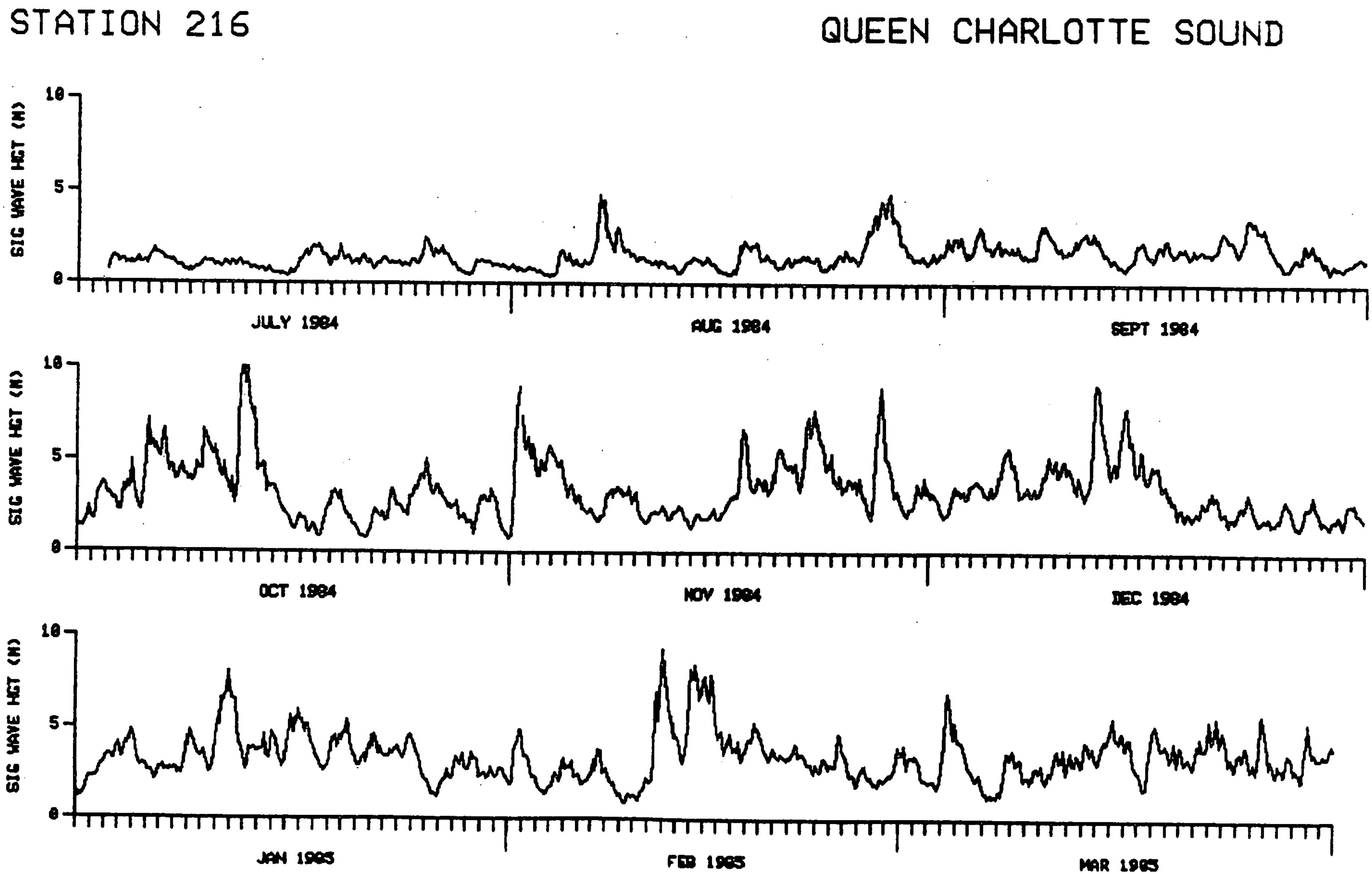


Figure 7. Time series of significant wave height during the study period at the Queen Charlotte Sound station.

when H_s exceeded 5 m; during this event the peak values for H_s and the zero-crossing wave height were 6.9 m and 10.8 m respectively. The wave climate during March was also more severe at Langara Island Station than at the Queen Charlotte Sound station.

Even though the monthly maximum H_s were largest at this station, the average H_s appear to be greater at Langara West Station than at the other locations; this may be due to the fact that storm waves were continuously sampled by the WAVEC buoy whereas WRIPS buoys only sampled at three hour intervals irrespective of the wave climate.

Comparative time series of wind and wave data (Appendix C) indicate only a weak correlation between significant wave height and Cape St. James winds. The correlation is not substantially better using the McKenny Rock wind data. The strongest correlations exist for strong winds from the south quadrant in a similar manner to that observed for Hecate Strait. The relatively poor correlations between wind speed from both McKenny Rock and Cape St. James, and the wave height suggests that offshore winds are not adequately represented by coastal wind stations. This observation is consistent with the conclusions of Hodgins et al. (1985) who noted that "shore station data are not adequate for verifying, or for incorporating directly into overwater wind fields".

CONCLUSIONS

1. Instrumentation used during this program proved to be reliable in most cases; data recovery was generally greater than 90%

2. The wave climate shows strongly seasonal variability; data suggests that there is "summer" period (June to September) of low waves (H_s <2 m) and a "winter" period (October to March) of significantly higher waves (H_s >3 m). Furthermore, the transition period from "summer" to "winter" conditions is very abrupt (i.e., October is one of the stormiest months of the year).

3. The stormiest portion of the study area is Queen Charlotte Sound. This area had the highest measured waves and longest duration of storms, although the Dixon Entrance area showed higher mean monthly H_s during the 1984/85 acquisition period.

APPENDIX A

Examples of Wave Data Products

This appendix provides examples and explanations of wave data plots and tables that were supplied in hard copy; calibrated time series and spectral data were supplied on magnetic tape. Products described in this appendix are grouped in terms of:

- time series plots;
- histograms;
- % occurrence and exceedance plots;
- persistance tables;
- tables of H_{rms} vs Tp;
- spectral plots for major storms.

Appropriate explanations are provided where required.

TIME SERIES

Figure A.1 indicates an example of a time series plot from the Queen Charlotte Sound Station showing H_s, Hmax, and T_p. For the directional wave buoy at the Langara station, an additional parameter, direction of the peak period is also presented. It is important to note that Hmax for the WRIPS buoy was taken directly from the GOES message and therefore does not include the buoy transfer function correction; in most cases, this correction is likely to be very small. For the WAVEC and Waverider buoys, a record mean was computed and wave heights were estimated from the zero crossing deviations; Hmax was taken as the largest of the estimated wave heights per wave record. As such, the transfer functions were not applied to account for filters in either the WAVEC or Waverider buoys (i.e., none of the Hmax estimates include buoy transfer functions). Figure A.2 illustrates an example of an expanded time series for a storm event at the Langara directional wave buoy site. A combined time series of wind and wave height was developed to illustrate wind and wave correlations (Figure A.3 and A.4).

HISTOGRAMS

An example of histograms for H_s and T_p, H_s vs θp and Tp vs θp are included in Figure A.5. For non-directional buoys only the H_s vs Tp histogram is included.

PERCENT OCCURRENCE AND EXCEEDANCE PLOTS

Examples of the monthly occurrence and exceedance plots are included in Figure A.6 for H_s and Tp. Figure A.7 illustrates the occurrence plot for θp.

PERSISTENCE TABLES

An example of persistence plots are given in Figure A.8 and indicate persistence of various wave height peak period and direction classes. As an example, Figure A.8 (top) indicates persistence of different significant wave height classes; specifically, there were four periods or occurrences when significant wave height was in the 0 to 2 m range and this wave height class occurred for 0 to 6 hours. There were nine occurrences of 4 to 6 m wave that were persisted from 6 to 12 hours.

Root-mean-square wave height versus peak period summary tables are indicated in Figure A.9.

SPECTRAL PLOTS

Spectral plots were generated for major storm events, as measured at each station. An example of a spectral plot is included in Figure A.10.

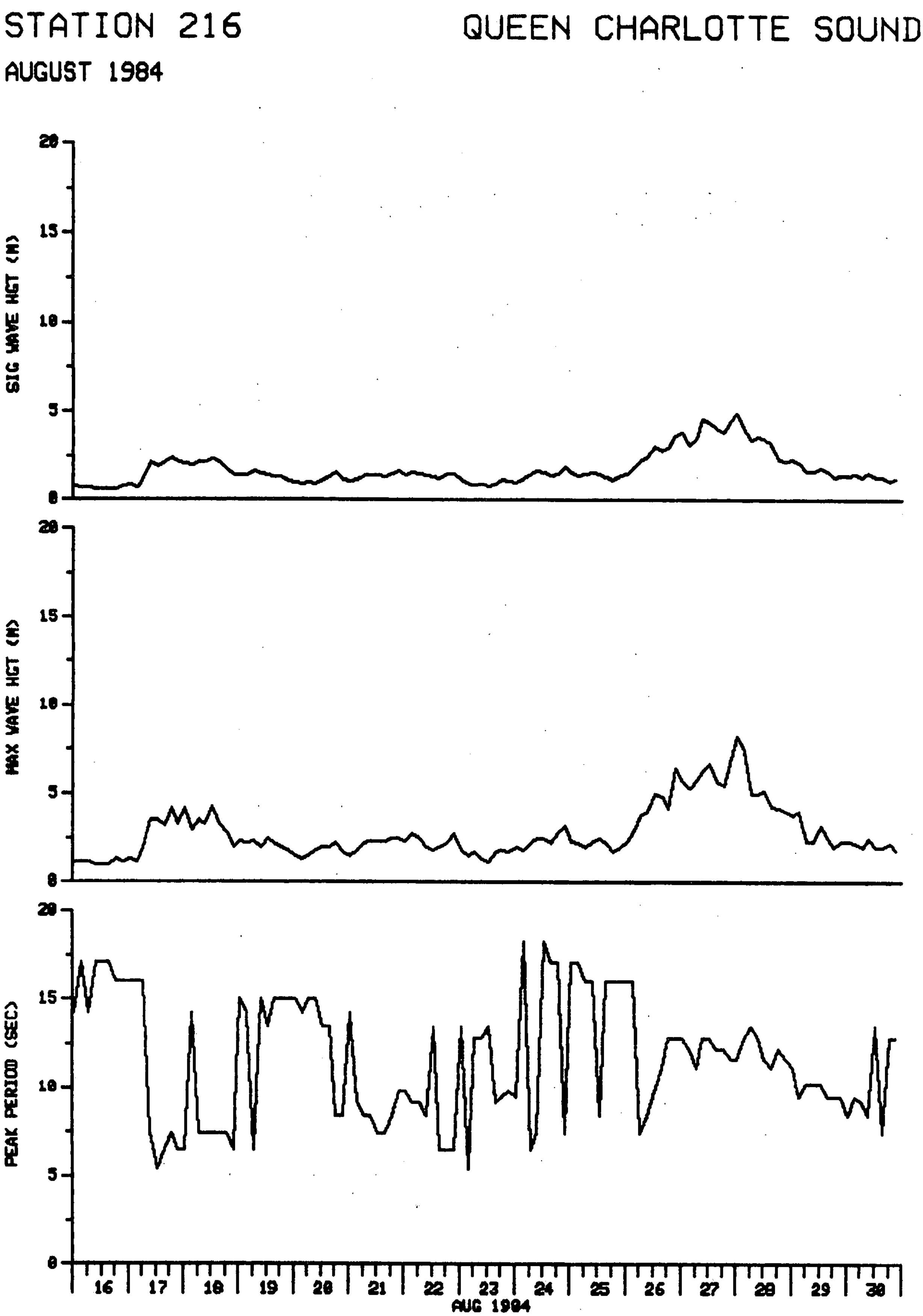


Figure A.1. Time series plot from WRIPS buoy.

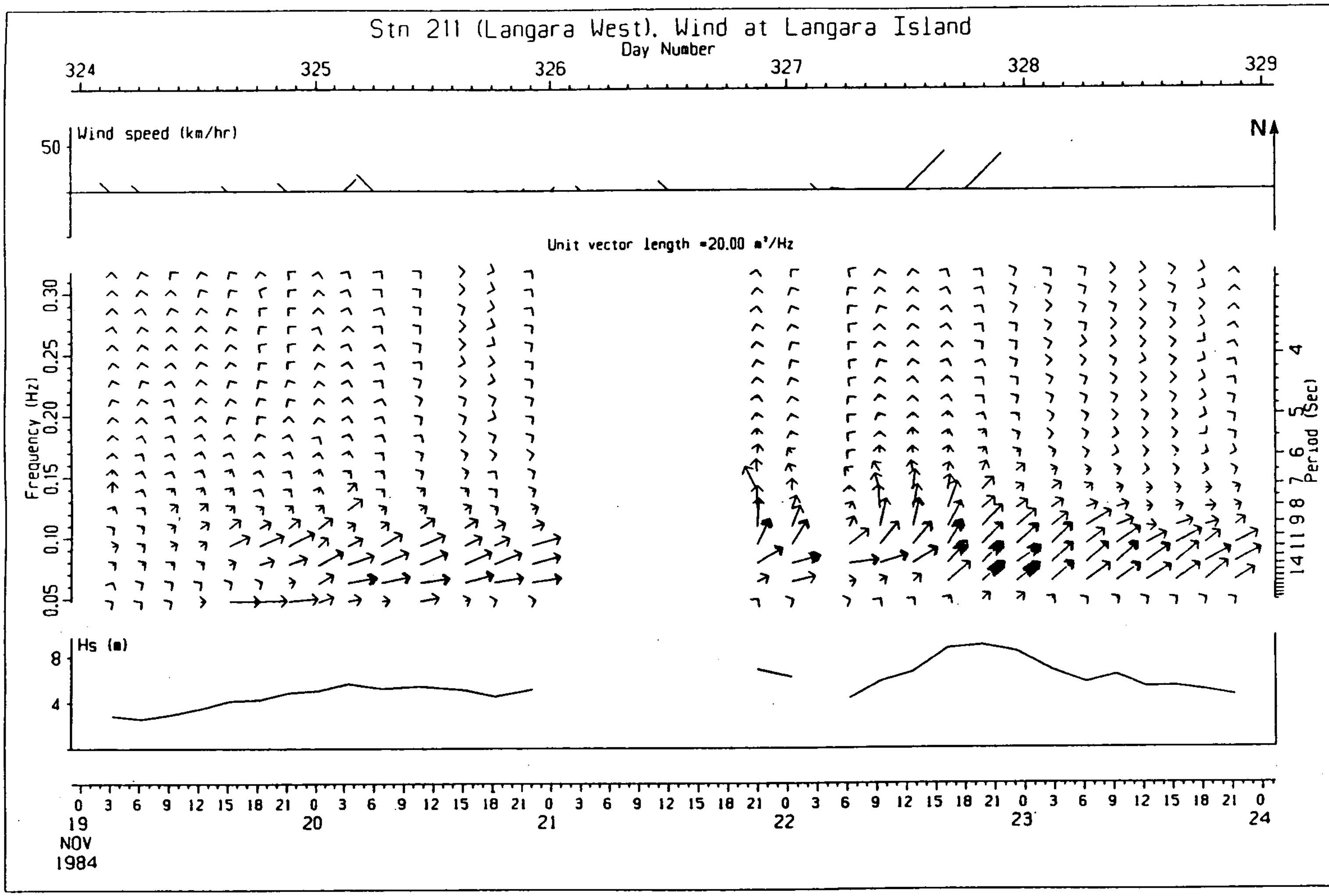


Figure A.2. Time series of wind (stick plots), peak period direction and significant wave height (Seaconsult Marine Research Ltd.).

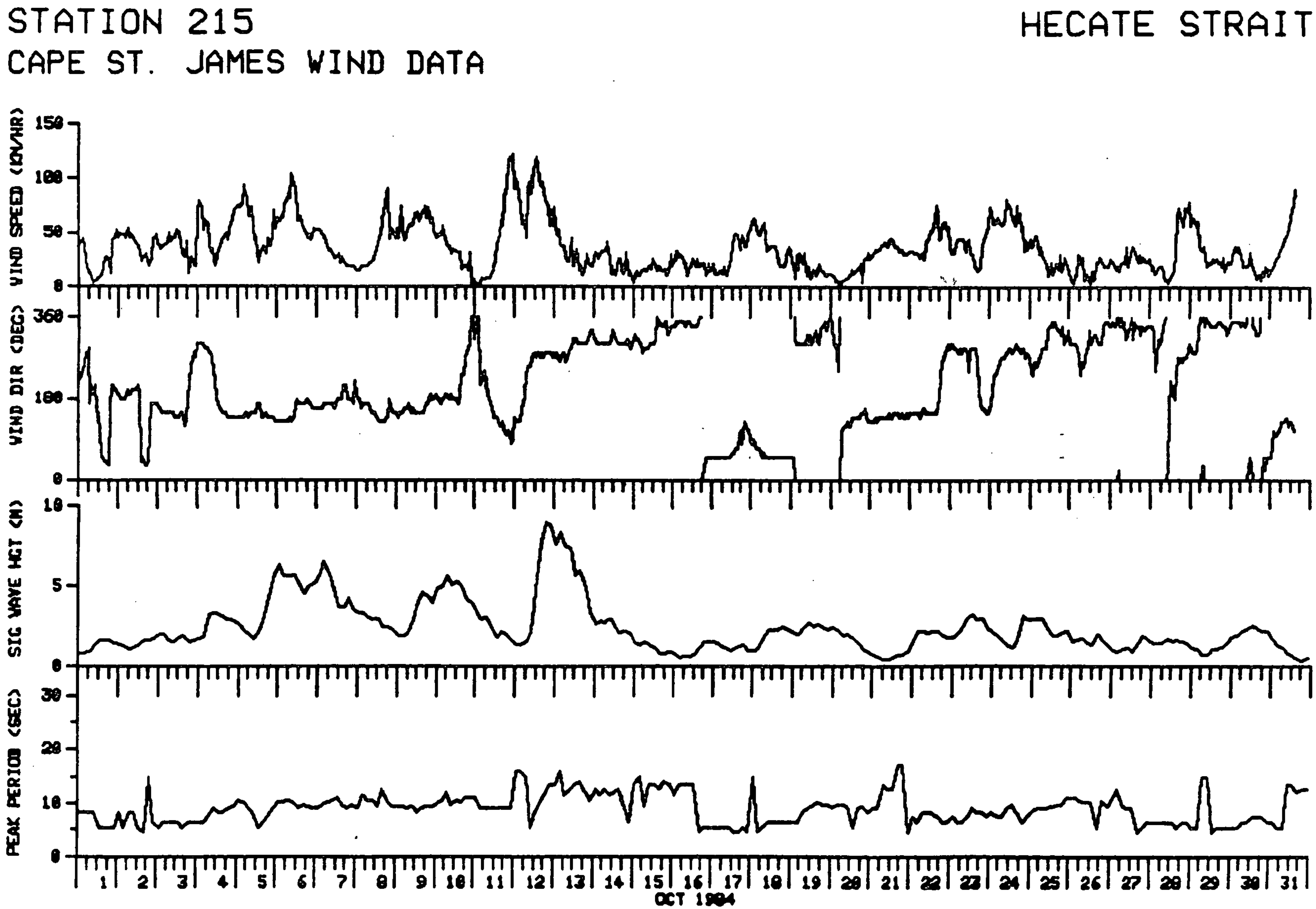


Figure A.3. Time series indicating wind and wave correlation for a non-directional wave buoy.

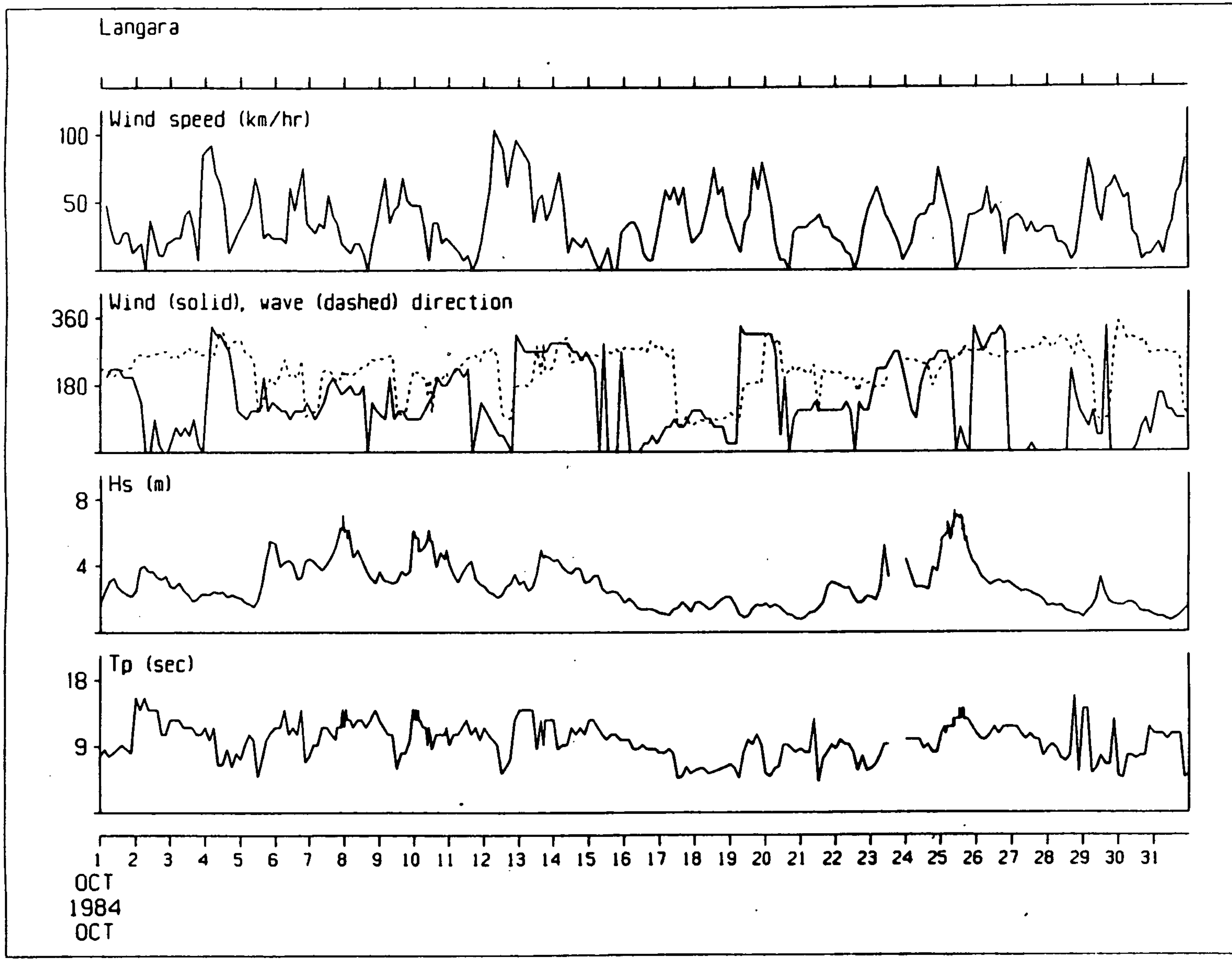


Figure A.4. Time series indicating wind and wave correlation for a directional wave buoy.

STATION 211 LANGARA WEST

OCTOBER 1984

PEAK PERIOD (SEC)	SIG WAVE HT (M) 0 to 2	2 to 4	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	18 to 20	
0 to 2											0
2 to 4											0
4 to 6	24	4									28
6 to 8	16	13	2								31
8 to 10	28	41	10								79
10 to 12	10	39	25	11							85
12 to 14	2	9	16	13							40
14 to 16	3	12	3	7							25
16 to 18											0
18 to 20											0
	83	118	56	31	0	0	0	0	0	0	288

DIRECTION (DEG)	SIG WAVE HGT (M) 0 to 2	2 to 4	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	18 to 20	
0 to 45											0
45 to 90	10	1									11
90 to 135	8	11	4								23
135 to 180	3	5	3								11
180 to 225	12	23	28	14							77
225 to 270	21	51	15	14							101
270 to 315	26	25	6	3							60
315 to 360	3	2									5
	83	118	56	31	0	0	0	0	0	0	288

DIRECTION (DEG)	PEAK PERIOD (SEC) 0 to 2	2 to 4	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	18 to 20	
0 to 45											0
45 to 90			10	1							11
90 to 135			8	10	5						23
135 to 180			1	2	5		1	2			11
180 to 225			2	4	23	26	15	7			77
225 to 270			1		19	50	19	12			101
270 to 315			3	12	27	9	5	4			60
315 to 360			3	2							5
	0	0	28	31	79	85	40	25	0	0	288

Figure A.5. Histograms for the Langara directional wave buoy.

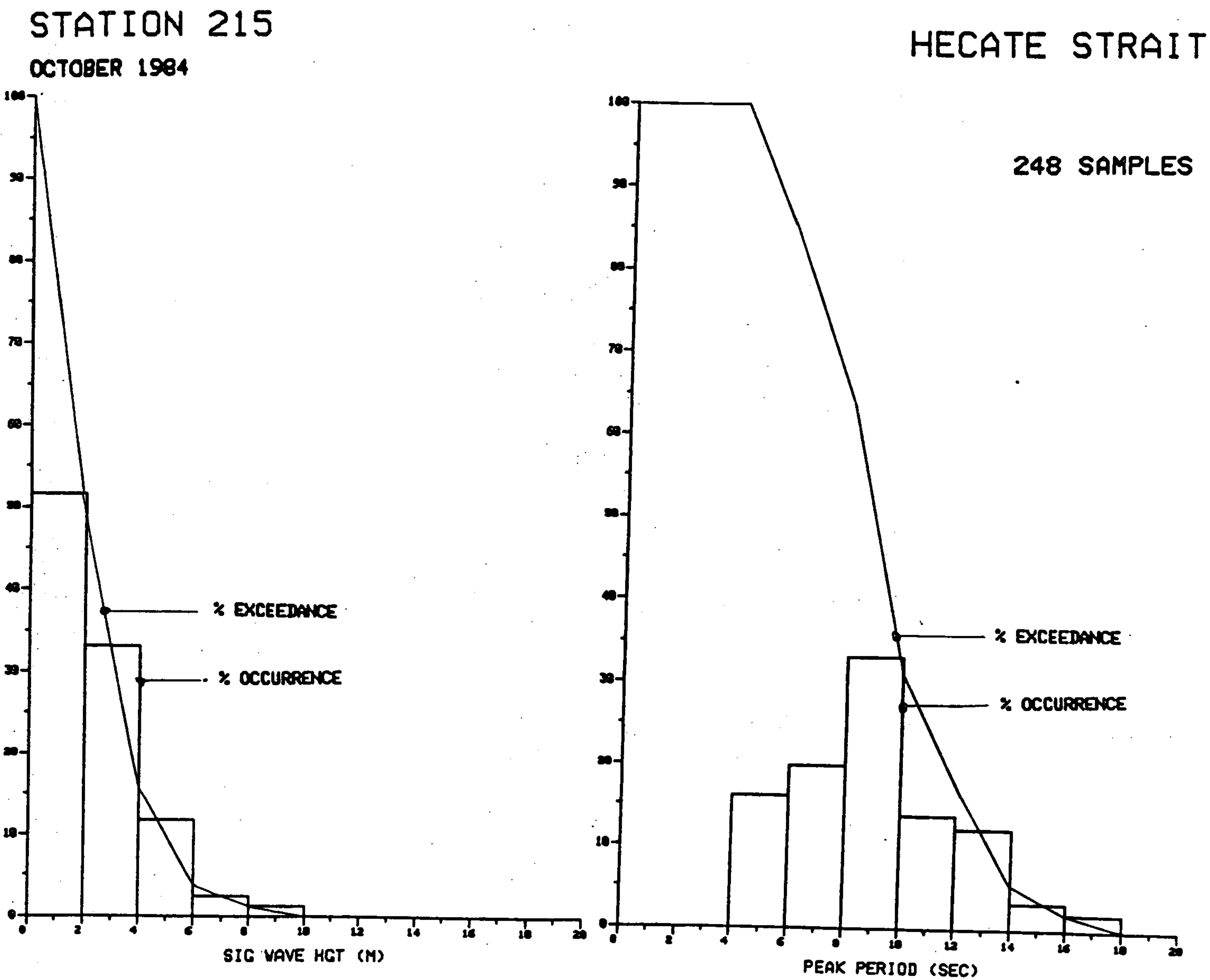


Figure A.6. Combined occurrence and exceedance plots.

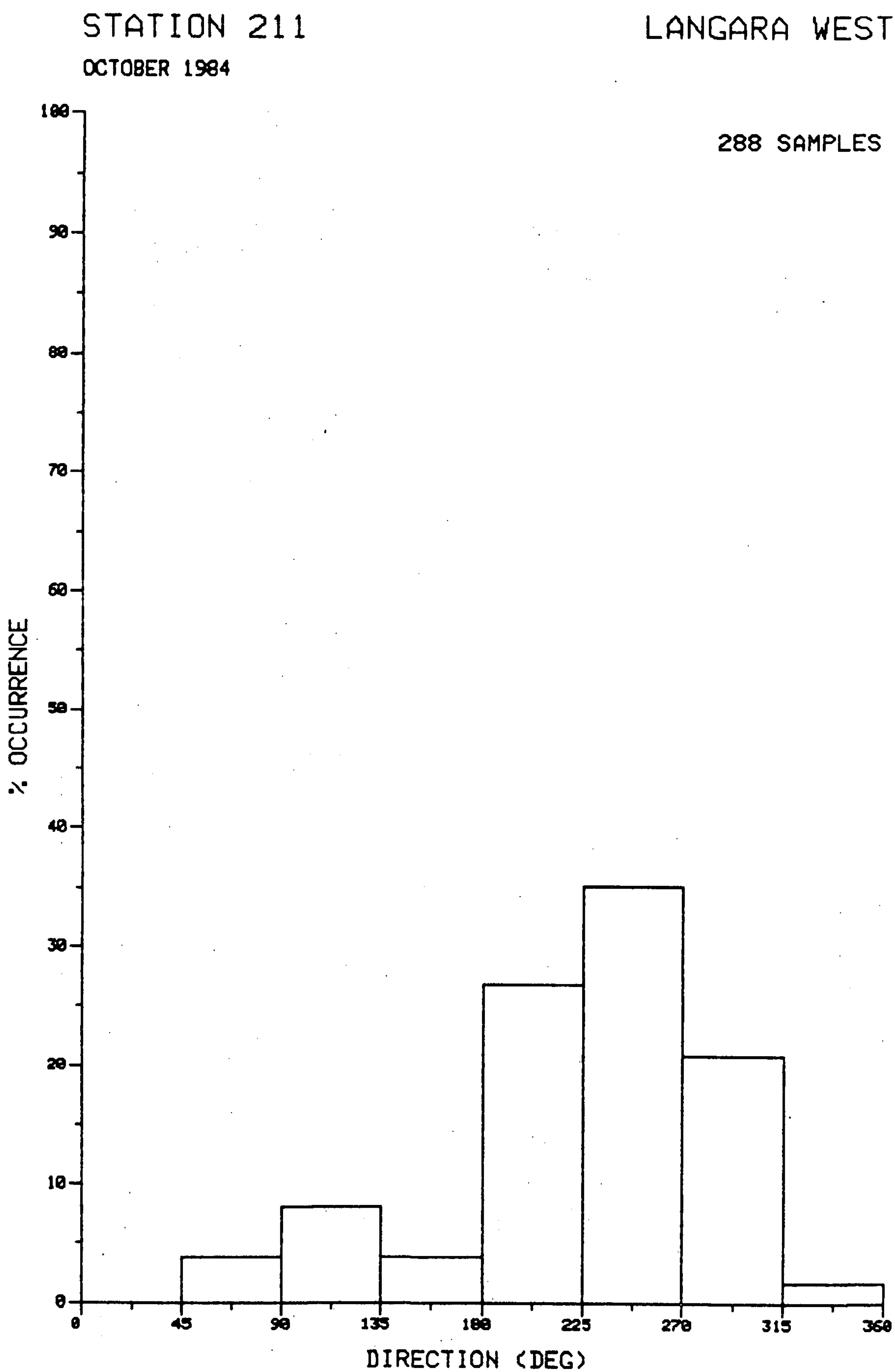


Figure A.7. Occurence plot of peak direction.

STATION 211 LANGARA WEST

OCTOBER 1984

Persistence of SIG WAVE HGT versus SIG WAVE HGT

SIG WAVE HGT (M)	PERSISTENCE (HOURS) 0 to 6	6 to 12	12 to 18	18 to 24	24 to 30	30 to 36	36 to 42	42 to 48	48 to 54	54 to 60	60 to 66	66 to 72	72 to 78	78 to 84	84 to 90	
0 to 2	4	1	1				1			1	2					10
2 to 4	6	5	1	3	1	2		2			1					21
4 to 6	6	9	1													16
6 to 8	5	1														6
8 to 10																0
10 to 12																0
12 to 14																0
14 to 16																0
16 to 18																0
18 to 20																0
	21	16	3	3	1	2	1	2	0	1	3	0	0	0	0	53

Persistence of PEAK PERIOD versus PEAK PERIOD

PEAK PERIOD (SEC)	PERSISTENCE (HOURS) 0 to 6	6 to 12	12 to 18	18 to 24	24 to 30	30 to 36	36 to 42	42 to 48	48 to 54	54 to 60	60 to 66	66 to 72	72 to 78	78 to 84	84 to 90	
0 to 2																0
2 to 4																0
4 to 6	7	6			1											14
6 to 8	10	7	1													18
8 to 10	18	10	1	3			1									33
10 to 12	12	14	3	1												30
12 to 14	17	4														21
14 to 16	11	1	1	1												14
16 to 18																0
18 to 20																0
	75	42	6	5	1	0	1	0	0	0	0	0	0	0	0	130

Persistence of DIRECTION versus DIRECTION

DIRECTION (DEG)	PERSISTENCE (HOURS) 0 to 6	6 to 12	12 to 18	18 to 24	24 to 30	30 to 36	36 to 42	42 to 48	48 to 54	54 to 60	60 to 66	66 to 72	72 to 78	78 to 84	84 to 90	
0 to 45																0
45 to 90	2	2	1													5
90 to 135	6	5	1													12
135 to 180	6	2														8
180 to 225	10	5	4	1	1											21
225 to 270	19	5	4	1	4											33
270 to 315	14	6	3				1									24
315 to 360	1	2														3
	58	27	13	2	5	0	1	0	0	0	0	0	0	0	0	106

Figure A.8. Persistence plots for Hs, Tp and peak direction.

Root Mean Square Wave Height (m) tabulated by wave period

OCT 84 Hour-day GMT	2 to 3 sec	3 to 4 sec	4 to 5 sec	5 to 6 sec	6 to 7 sec	7 to 8 sec	8 to 9 sec	9 to 11 sec	11 to 13 sec	13 to 16 sec	16 to 20 sec	20 to 30 sec	Sig. Wave Ht in m	Peak Per in sec
2101- 6	0.14	0.20	0.24	0.34	0.50	0.37	0.23	0.39	0.39	0.38	0.13	0.11	4.28	6.83
1- 7	0.15	0.20	0.27	0.44	0.37	0.44	0.35	0.49	0.35	0.26	0.13	0.09	4.44	7.61
301- 7	0.14	0.19	0.22	0.36	0.37	0.36	0.42	0.55	0.34	0.20	0.08	0.08	4.29	9.18
601- 7	0.14	0.18	0.19	0.30	0.30	0.40	0.34	0.54	0.31	0.23	0.07	0.07	3.98	9.18
901- 7	0.12	0.17	0.22	0.31	0.40	0.30	0.29	0.40	0.38	0.20	0.07	0.08	3.75	11.58
1201- 7	0.13	0.19	0.23	0.28	0.33	0.29	0.29	0.48	0.57	0.20	0.08	0.08	4.14	11.58
1501- 7	0.15	0.20	0.24	0.38	0.32	0.33	0.45	0.62	0.49	0.16	0.07	0.08	4.63	10.65
1801- 7	0.14	0.19	0.25	0.37	0.39	0.39	0.42	0.76	0.56	0.22	0.10	0.11	5.20	9.86
1926- 7	0.12	0.18	0.23	0.40	0.41	0.43	0.49	0.73	0.65	0.22	0.08	0.10	5.48	11.58
2026- 7	0.12	0.19	0.24	0.35	0.43	0.38	0.51	0.75	0.80	0.31	0.09	0.11	5.84	11.66
2101- 7	0.13	0.18	0.23	0.38	0.40	0.46	0.42	0.80	0.89	0.38	0.11	0.13	6.18	11.66
2136- 7	0.13	0.19	0.23	0.38	0.45	0.42	0.43	0.78	0.93	0.39	0.12	0.13	6.30	11.66
2211- 7	0.13	0.19	0.22	0.35	0.46	0.40	0.41	0.81	0.85	0.49	0.11	0.14	6.22	11.66
2266- 7	0.15	0.20	0.24	0.37	0.44	0.42	0.40	0.75	0.88	0.56	0.13	0.15	6.29	12.68
2313- 7	0.14	0.20	0.26	0.35	0.36	0.38	0.48	0.75	0.78	0.67	0.16	0.16	6.21	14.14
2348- 7	0.14	0.20	0.24	0.36	0.37	0.39	0.44	0.68	1.09	0.85	0.17	0.19	7.11	12.78
23- 8	0.13	0.19	0.25	0.33	0.37	0.39	0.46	0.67	0.80	0.64	0.17	0.16	6.04	12.68
50- 8	0.13	0.18	0.23	0.32	0.31	0.33	0.41	0.57	0.95	0.74	0.18	0.16	6.19	11.66
125- 8	0.13	0.19	0.25	0.30	0.29	0.30	0.36	0.58	0.85	0.88	0.17	0.16	6.19	14.14
200- 8	0.13	0.18	0.22	0.30	0.33	0.36	0.35	0.70	0.90	0.66	0.16	0.15	6.13	12.78
235- 8	0.14	0.19	0.22	0.31	0.31	0.27	0.33	0.54	0.84	0.70	0.14	0.14	5.66	12.78
310- 8	0.14	0.18	0.20	0.35	0.29	0.31	0.37	0.69	0.90	0.74	0.17	0.15	6.20	12.68
413- 8	0.13	0.19	0.21	0.22	0.24	0.29	0.31	0.58	0.83	0.65	0.13	0.13	5.46	12.68
601- 8	0.12	0.16	0.18	0.23	0.27	0.24	0.22	0.43	0.77	0.42	0.13	0.11	4.52	11.58
901- 8	0.11	0.17	0.20	0.29	0.27	0.20	0.32	0.58	0.73	0.52	0.11	0.12	4.97	12.68
1201- 8	0.11	0.15	0.18	0.25	0.24	0.26	0.26	0.50	0.64	0.44	0.11	0.10	4.39	12.68
1501- 8	0.11	0.14	0.16	0.20	0.21	0.21	0.30	0.57	0.48	0.20	0.09	0.08	3.76	11.58
1801- 8	0.09	0.13	0.13	0.15	0.20	0.16	0.24	0.43	0.45	0.27	0.13	0.09	3.29	12.68
2101- 8	0.09	0.11	0.14	0.16	0.17	0.19	0.19	0.33	0.34	0.37	0.13	0.09	2.96	14.01
1- 9	0.10	0.14	0.15	0.20	0.22	0.14	0.21	0.42	0.49	0.45	0.11	0.09	3.67	12.68
301- 9	0.10	0.14	0.17	0.19	0.16	0.15	0.25	0.42	0.40	0.24	0.06	0.07	3.11	11.58
601- 9	0.09	0.17	0.19	0.16	0.17	0.18	0.19	0.41	0.40	0.23	0.07	0.06	3.05	10.65
901- 9	0.10	0.14	0.20	0.33	0.18	0.13	0.19	0.39	0.26	0.21	0.05	0.05	2.95	10.65
1201- 9	0.14	0.22	0.27	0.38	0.32	0.19	0.14	0.24	0.22	0.17	0.05	0.05	3.05	5.92
1501- 9	0.12	0.18	0.23	0.37	0.37	0.42	0.42	0.21	0.25	0.12	0.04	0.07	3.69	8.07
1801- 9	0.10	0.16	0.23	0.30	0.30	0.36	0.40	0.34	0.22	0.13	0.04	0.06	3.43	8.07
2101- 9	0.12	0.18	0.19	0.29	0.41	0.33	0.28	0.52	0.23	0.11	0.07	0.06	3.71	9.86
2356- 9	0.17	0.20	0.25	0.31	0.39	0.35	0.26	0.50	0.75	0.93	0.21	0.17	6.12	14.14
31- 10	0.16	0.21	0.24	0.33	0.37	0.30	0.29	0.54	0.84	0.83	0.24	0.21	6.09	12.78
106- 10	0.16	0.20	0.24	0.33	0.37	0.39	0.32	0.56	0.69	0.73	0.18	0.14	5.66	14.14
143- 10	0.16	0.19	0.24	0.28	0.31	0.41	0.37	0.59	0.78	0.70	0.17	0.17	5.80	12.68
301- 10	0.15	0.21	0.24	0.35	0.37	0.43	0.39	0.56	0.68	0.69	0.16	0.15	5.68	14.01
336- 10	0.14	0.18	0.24	0.33	0.30	0.34	0.32	0.51	0.67	0.46	0.16	0.14	4.89	12.68
426- 10	0.13	0.19	0.24	0.35	0.34	0.34	0.35	0.46	0.68	0.48	0.11	0.12	4.92	12.68
601- 10	0.12	0.17	0.21	0.31	0.35	0.44	0.39	0.57	0.68	0.36	0.10	0.12	5.06	11.58
851- 10	0.12	0.18	0.23	0.33	0.35	0.47	0.59	0.70	0.56	0.28	0.09	0.10	5.37	11.66
944- 10	0.12	0.19	0.23	0.32	0.45	0.50	0.60	0.76	0.61	0.32	0.10	0.12	5.79	9.18
1038- 10	0.14	0.20	0.26	0.36	0.50	0.56	0.65	0.78	0.65	0.28	0.11	0.13	6.18	11.66

Figure A.9. Tabular summaries of H_{rms} versus Tp.

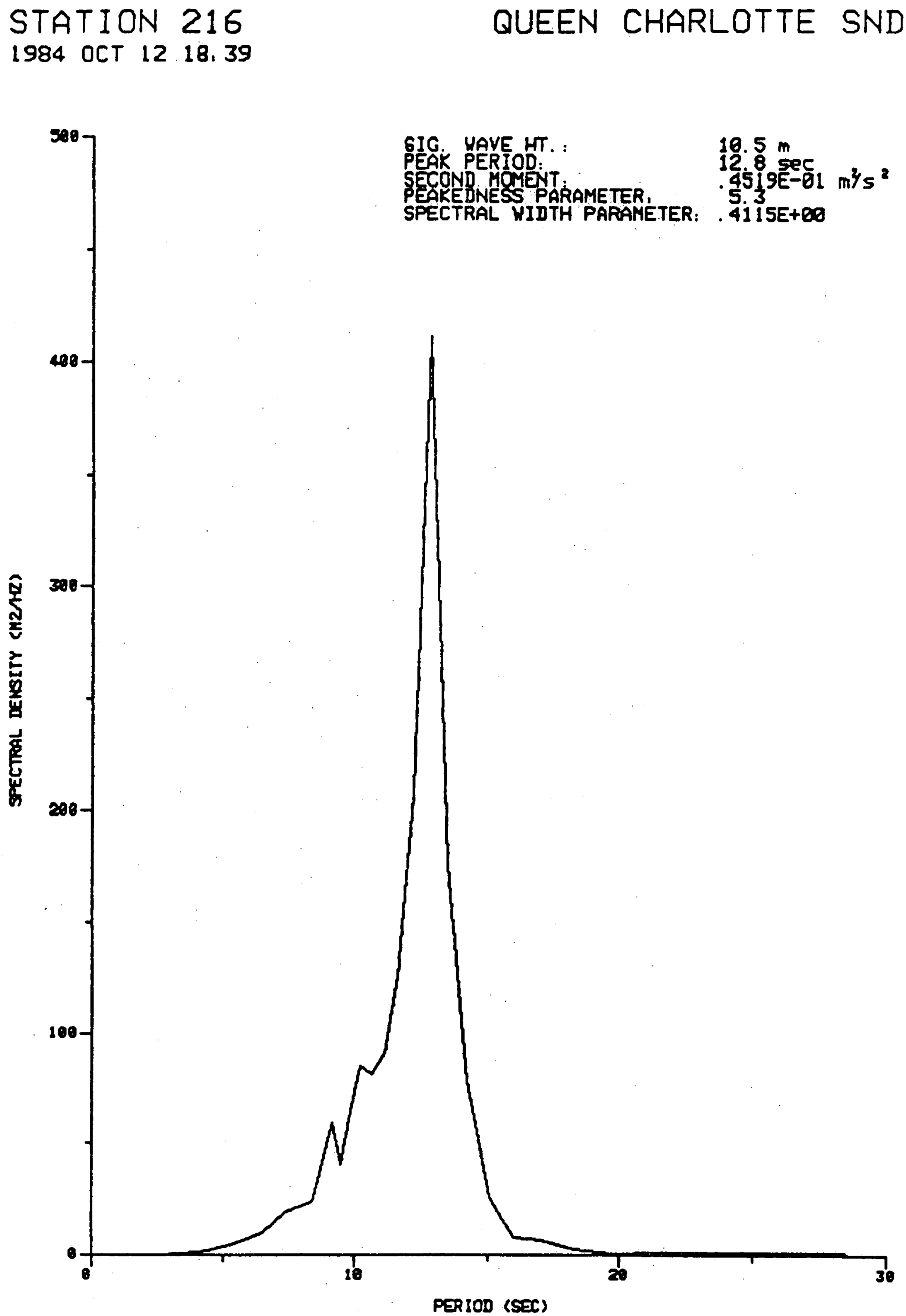


Figure A.10. An example of a spectral plot for the 12 October, 1984, storm at the Queen Charlotte Sound station.

APPENDIX B

Examples of Wind Data Products

This appendix provides examples of wind data plots and tables that were supplied in hardcopy; calibrated time series and spectral data were supplied on magnetic tape to MEDS. Figure B.1 indicates typical time series of wind speed and direction (as indicated by stick plots), air temperature, dew point and relative humidity. Figure B.2 indicates histograms of direction versus speed and persistence tables of speed and direction. Figure B.3 provides examples of occurrence and exceedance plots for wind speed and direction. Figure B.4 illustrates a 15-day hourly wind summary.

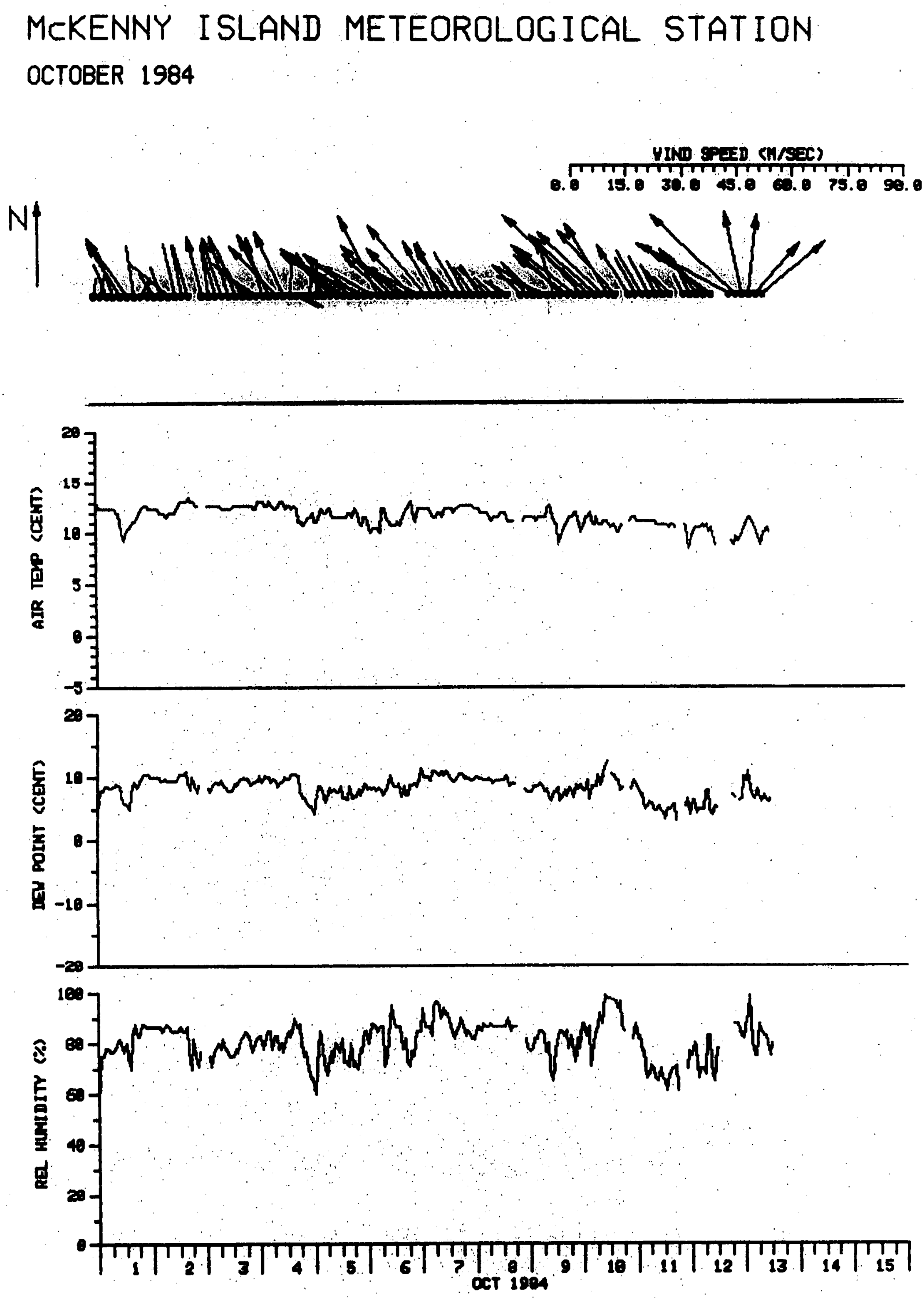


Figure B.1. Time series of selected meteorological parameters.

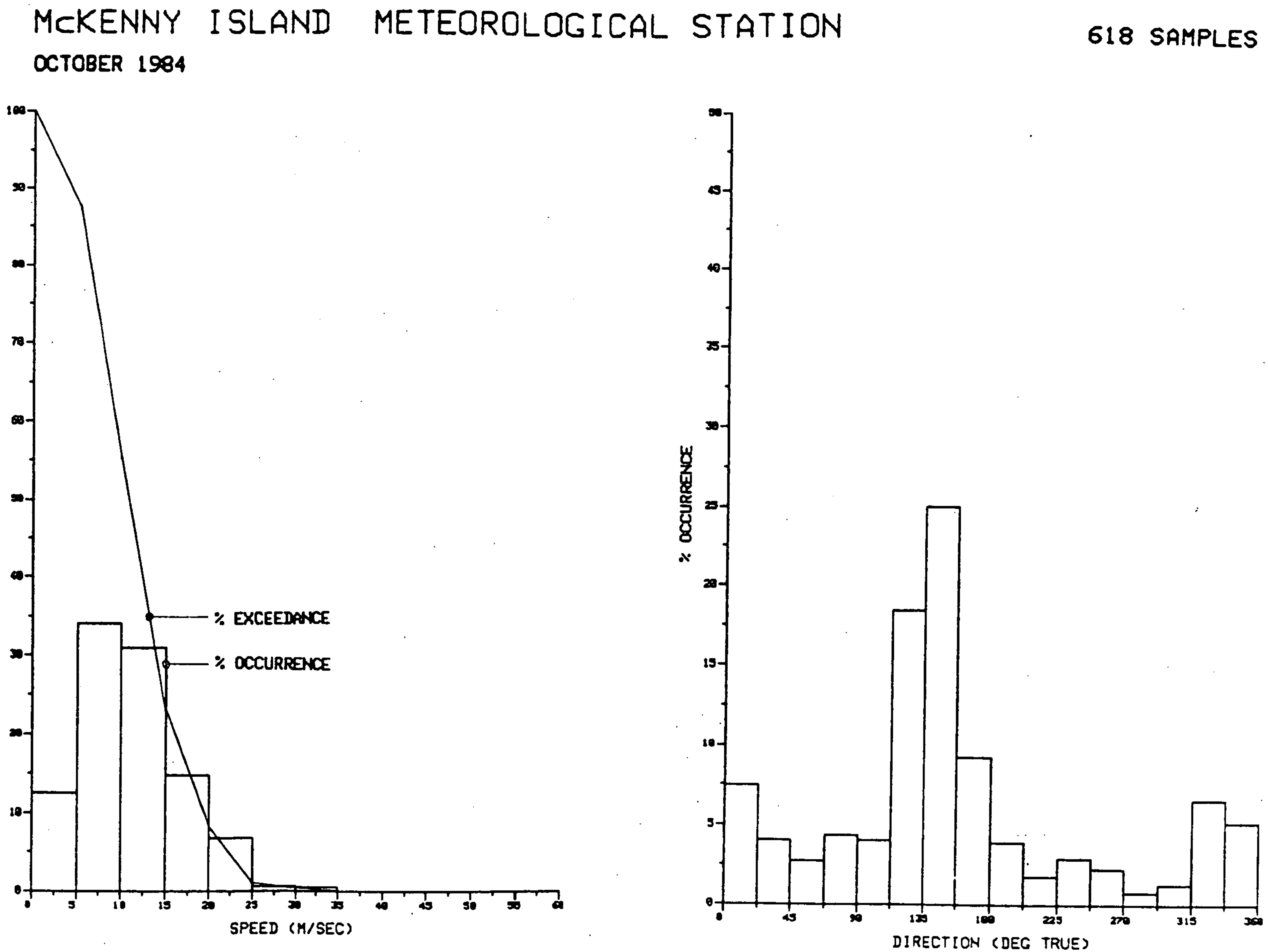


Figure B.3. Occurrence and exceedance plots for wind speed and direction.

McKENNY ISLAND METEOROLOGICAL STATION

OCTOBER 1984

DIRECTION (DEG TRUE))	0 to 5	5 to 10	10 to 15	15 to 20	20 to 25	25 to 30	30 to 35	35 to 40	40 to 45	45 to 50	
	SPEED (M/SEC)										
0.0 to 22.5	1	15	30								46
22.5 to 45.0	2	22	1								25
45.0 to 67.5	4	13									17
67.5 to 90.0	7	14	6								27
90.0 to 112.5	7	8	5	4							24
112.5 to 135.0	11	19	40	28	11	2	3				114
135.0 to 157.5	6	28	56	41	22	2					155
157.5 to 180.0	3	12	26	14	2						57
180.0 to 202.5	9	7	3	1	4						24
202.5 to 225.0	1	6	3	1							11
225.0 to 247.5	5	3	5	2	3						18
247.5 to 270.0	5	6	3								14
270.0 to 292.5	2		3								5
292.5 to 315.0	5	3									8
315.0 to 337.5	5	32	4								41
337.5 to 360.0	4	22	6								32
	77	210	191	91	42	4	3	0	0	0	618

SPEED (M/SEC)	0 to 6	6 to 12	12 to 18	18 to 24	24 to 30	30 to 36	36 to 42	42 to 48	48 to 54	54 to 60	60 to 66	66 to 72	72 to 78	78 to 84	84 to 90	
	PERSISTENCE (HOURS)															
0 to 5	13	4	1													18
5 to 10	38	8	2	2												50
10 to 15	40	6	4													50
15 to 20	28	4														32
20 to 25	14		1													15
25 to 30	2															2
30 to 35	2															2
35 to 40																0
40 to 45																0
45 to 50																0
50 to 55																0
55 to 60																0
	137	22	8	2	0	0	0	0	0	0	0	0	0	0	0	169

DIRECTION (DEG TRUE))	0 to 6	6 to 12	12 to 18	18 to 24	24 to 30	30 to 36	36 to 42	42 to 48	48 to 54	54 to 60	60 to 66	66 to 72	72 to 78	78 to 84	84 to 90	
	PERSISTENCE (HOURS)															
0.0 to 22.5	5		1	1												7
22.5 to 45.0	7	1														8
45.0 to 67.5	11															11
67.5 to 90.0	8	1														9
90.0 to 112.5	12															12
112.5 to 135.0	29	3	2													34
135.0 to 157.5	32	9	1													42
157.5 to 180.0	22	1	1													24
180.0 to 202.5	11															11
202.5 to 225.0	8															8
225.0 to 247.5	10															10
247.5 to 270.0	9															9
270.0 to 292.5	4															4
292.5 to 315.0	6															6
315.0 to 337.5	15	2														17
337.5 to 360.0	16	1														17
	205	18	5	1	0	0	0	0	0	0	0	0	0	0	0	229

Figure B.2. Wind-data histogram (top) and persistence tables (middle and bottom).

16 POINT WIND SUMMARY FOR McKENNY ISLAND
OCT 1984

ELEVATION : 19 M
LOCATION : 52 39 N 129 28 W
STATION CODE : 4559E572

WIND - KM/HR

HOUR / DAY	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	MEAN SPD	MAX SPD	PREV DIR	MISS OBS
1	7	12	17	16	19	20	22	27	32	37	45	43	55	59	60	67	63	67	69	61	48	35	27	18	39	69		0
	S	S	SSW	S	S	SSW	S	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SE	SE	SSE	SSE	S	S	SSW	SSW			SSE	0
2	17	18	17	17	21	26	25	26	29	38	39	49	43	48	51	52	51	49	50	51	50	48	M	M	37	52		2
	S	S	S	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SE	SE	SSE	S	SSE	S	S	S	SSE	SSE	SSE	SSE	M	M			SSE	2
3	M	58	59	51	52	48	46	48	47	51	59	59	53	56	60	55	43	46	42	41	45	45	39	46	50	60		1
	M	SSE	SSE	SSE	S	S	S	S	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SE	SE	SSE	SE	SE	SE			SSE	1
4	41	40	42	39	57	57	46	37	66	63	53	65	76	77	66	59	57	33	37	29	24	28	28	22	48	77		0
	SE	SE	ESE	SE	SSE	SSE	SE	ESE	SSE	SSE	SE	SE	SE	SE	SSE	SSE	SSE	S	W	W	WNW	NW	NW	WNW			SE	0
5	9	31	29	22	21	32	30	43	48	53	59	60	65	61	70	74	70	73	74	70	72	64	65	65	53	74		0
	WNW	SSW	S	S	S	S	SSE	SSE	SSE	SE	SE	SE	SE	SE	SE	SE	SE	SE	ESE	ESE	ESE	ESE	SE	SE			SE	0
6	81	64	55	59	70	59	58	76	84	74	82	55	71	65	67	47	46	53	50	46	48	59	47	62	62	84		0
	SE	ESE	ESE	ESE	ESE	ESE	SE	SSE	SSE	SSE	SSE	SE	SE	SE	SE	SE	ESE	SE	ESE	SE	SE	SE	SE	SE			SE	0
7	62	55	60	68	60	87	88	63	58	60	55	54	51	49	57	54	49	51	50	51	47	41	40	36	56	88		0
	SE	ESE	ESE	SE	SE	SE	SSE	S	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SE	SSE	SSE	SSE	SSE	SSE	SSE			SSE	0
8	34	29	30	28	26	33	37	40	37	34	35	24	21	22	16	21	25	23	23	M	M	M	36	35	29	40		3
	SSE	SSE	SE	SE	SSE	SSE	SE	SE	SE	SE	SE	SE	SSE	SSE	SE	SE	ESE	ESE	ESE	M	M	M	SE	SE			SE	3
9	32	35	39	38	42	43	54	54	53	48	47	51	60	52	55	55	66	66	68	74	63	62	78	68	54	78		0
	SE	SE	SE	SE	SE	SE	SE	SE	ESE	ESE	ESE	ESE	ESE	ESE	SSE	SE	SE	SE	SE	SE	SE	SE	SE	SE			SE	0
10	71	76	72	73	79	112	79	75	84	80	79	86	84	86	79	81	79	82	79	M	M	M	58	56	79	112		3
	SE	SSE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SSE	SE	SE	SE	SE	M	M	M	SSE	SSE			SE	3
11	54	50	40	46	46	49	46	39	40	37	32	31	27	20	26	18	21	22	24	M	M	M	17	21	34	54		3
	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SE	SE	SE	SE	SE	M	M	M	SSE	SSE			SSE	3
12	16	13	36	42	40	45	46	55	60	44	43	72	61	M	M	M	M	M	M	101	101	111	112	99	61	112		6
	SSE	ESE	SSE	SSE	SE	SE	SSE	SSE	SE	ESE	ESE	SE	ESE	M	M	M	M	M	M	ESE	ESE	SE	SE	SE			SE	6
13	93	81	72	74	76	77	87	64	61	71	79	85	84	M	M	M	M	M	M	M	M	M	M	M	77	93		11
	SE	SSE	S	S	S	S	SSW	SW	WSW	SW	SW	SW	SW	M	M	M	M	M	M	M	M	M	M	M			SW	11
14	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M		24
	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M			M	24
15	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M		24
	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M			M	24

NOTE: MISSING DATA (M) NO PREVAILING WIND DIRECTION (SVL) CALM WIND (C)

Figure B.4. Hourly wind data summary from the McKenny Island weather station.

APPENDIX C

Wave and Wind Data Time Series

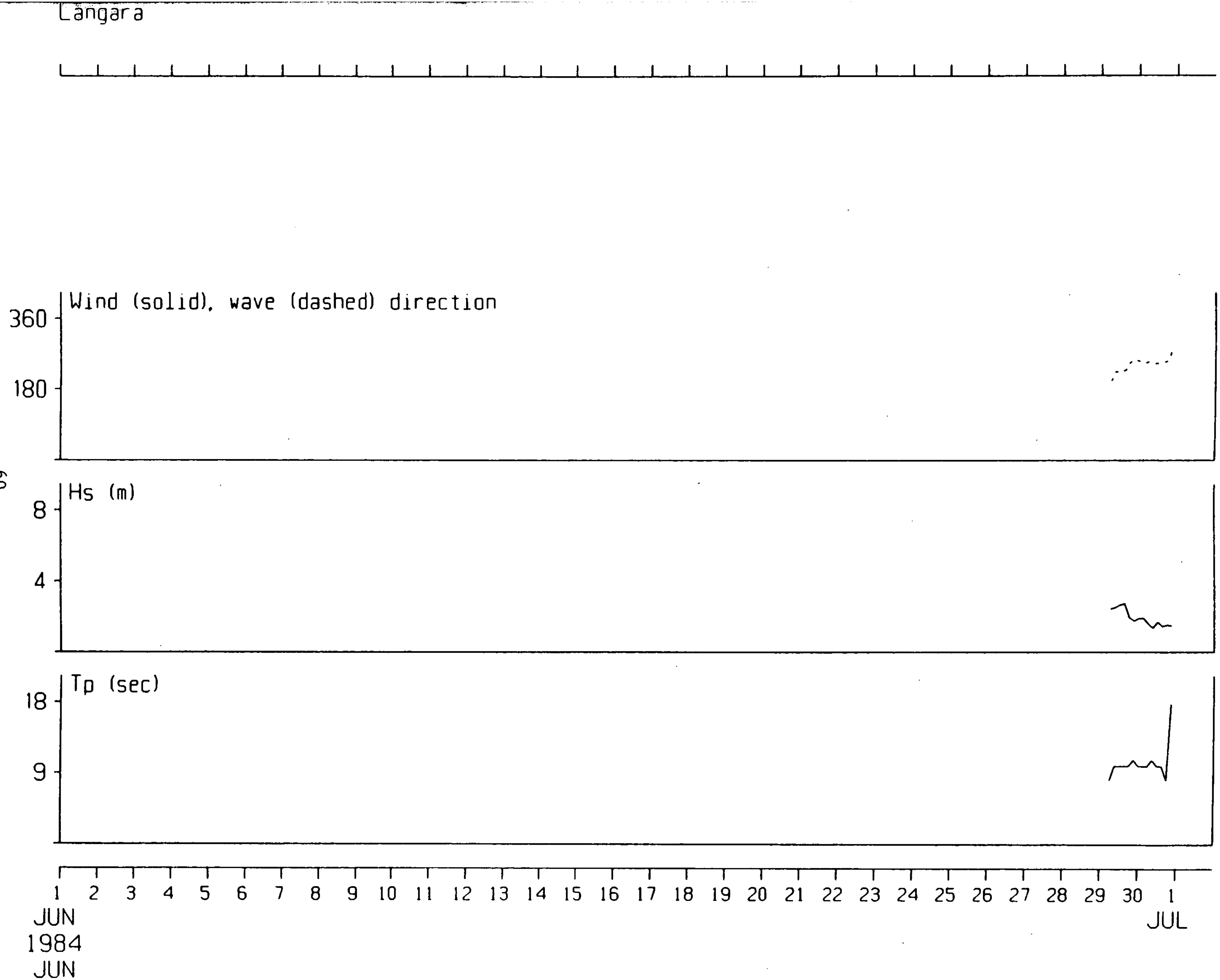
To facilitate review of the wave data, time series of H_s and Tp are presented for each station. Wind speed and direction time series from the nearest weather station are also included to provide an index of wind wave correlations. The time series data are arranged in the following order:

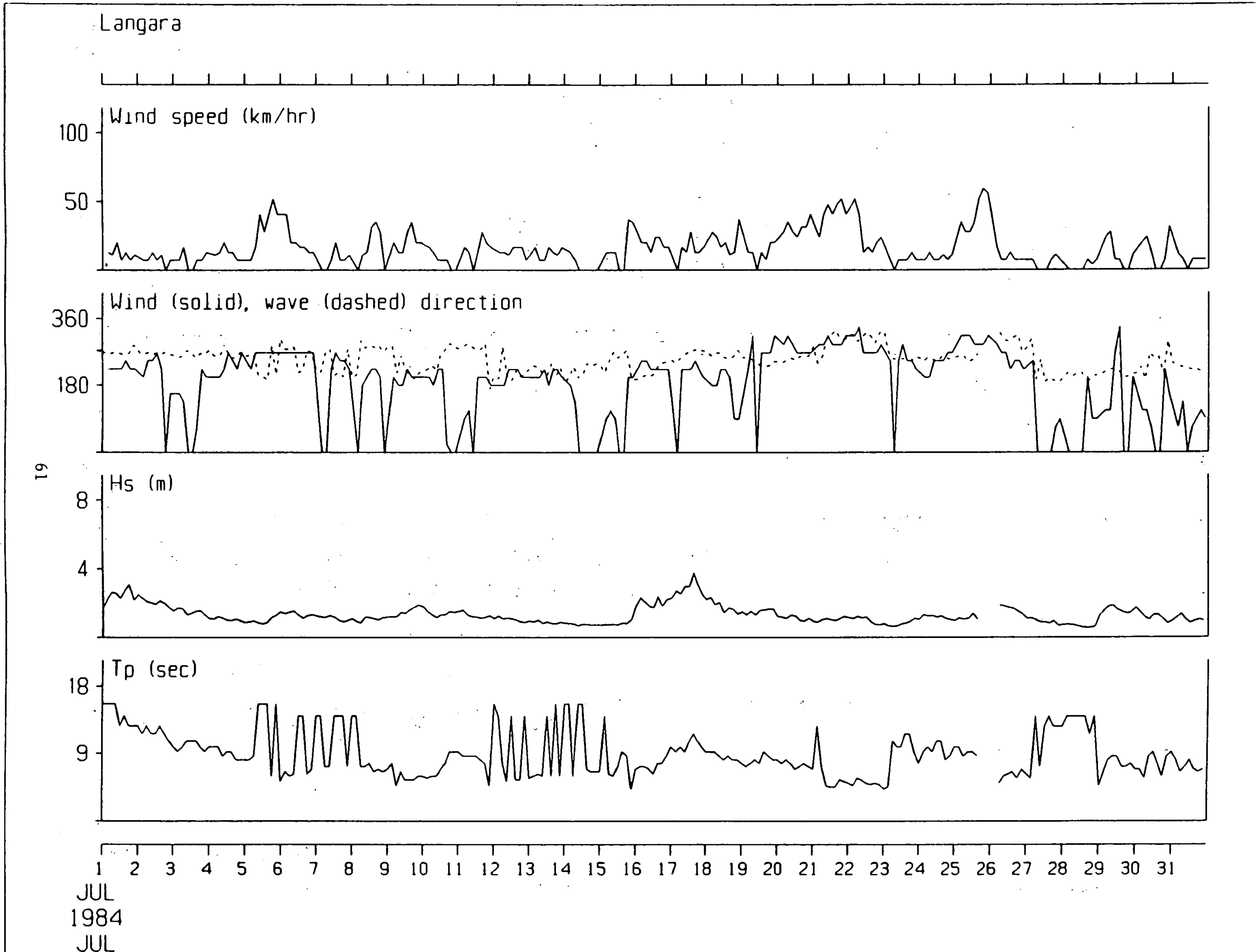
1. Langara West (Station 211)

2. Bonilla Island (Station 213)

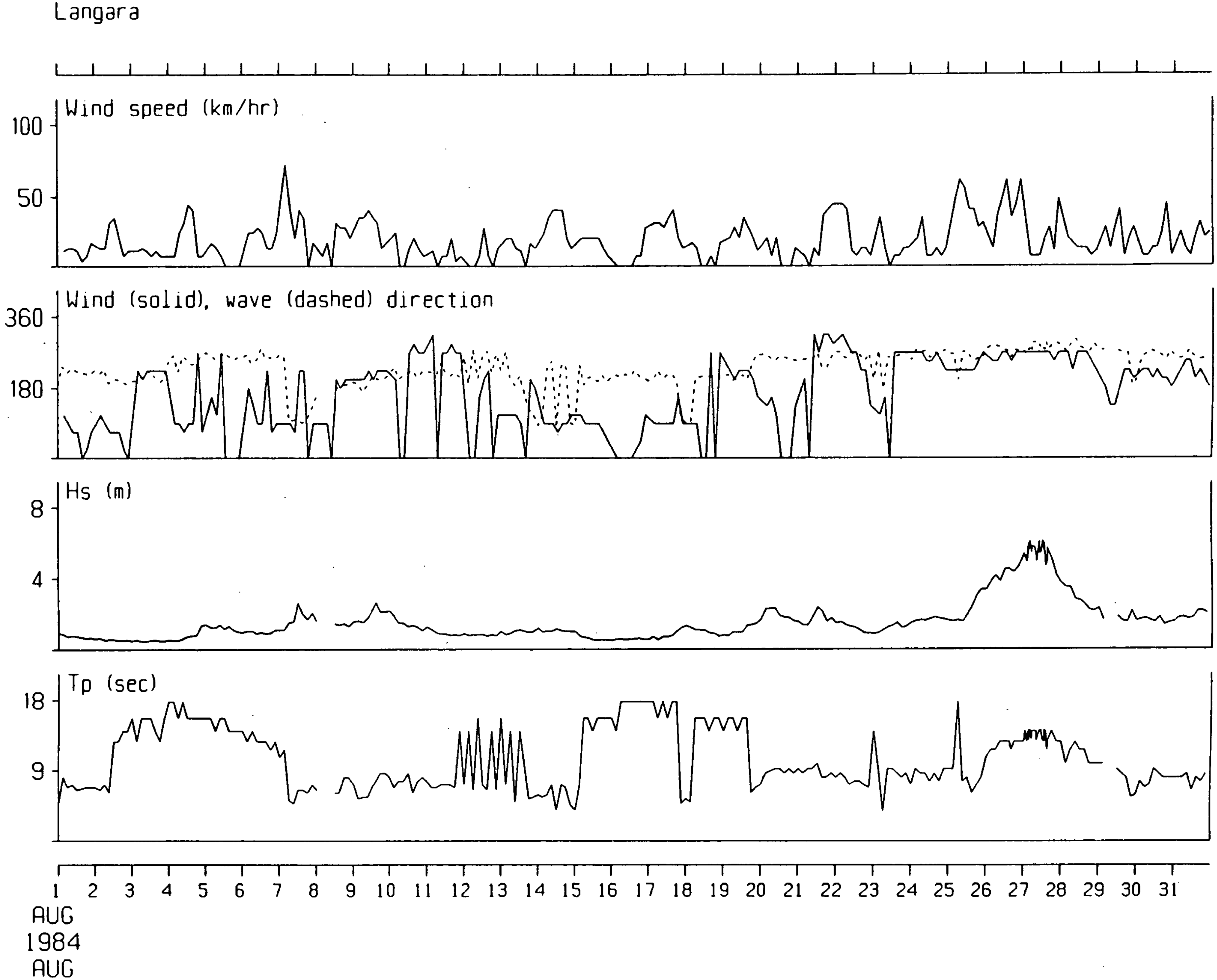
3. Hecate Strait (Section 215)

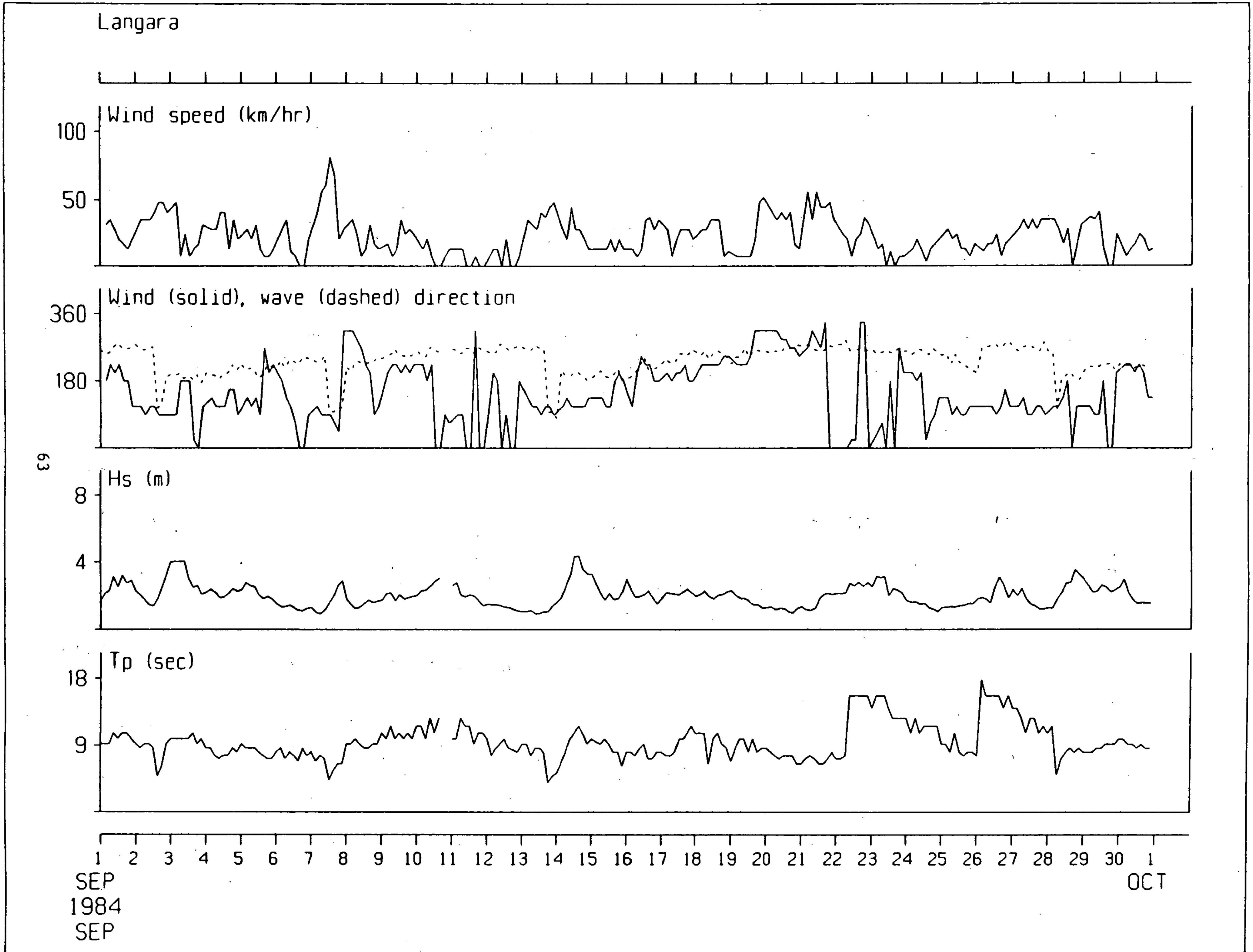
4. Queen Charlotte Sound (Station 216)

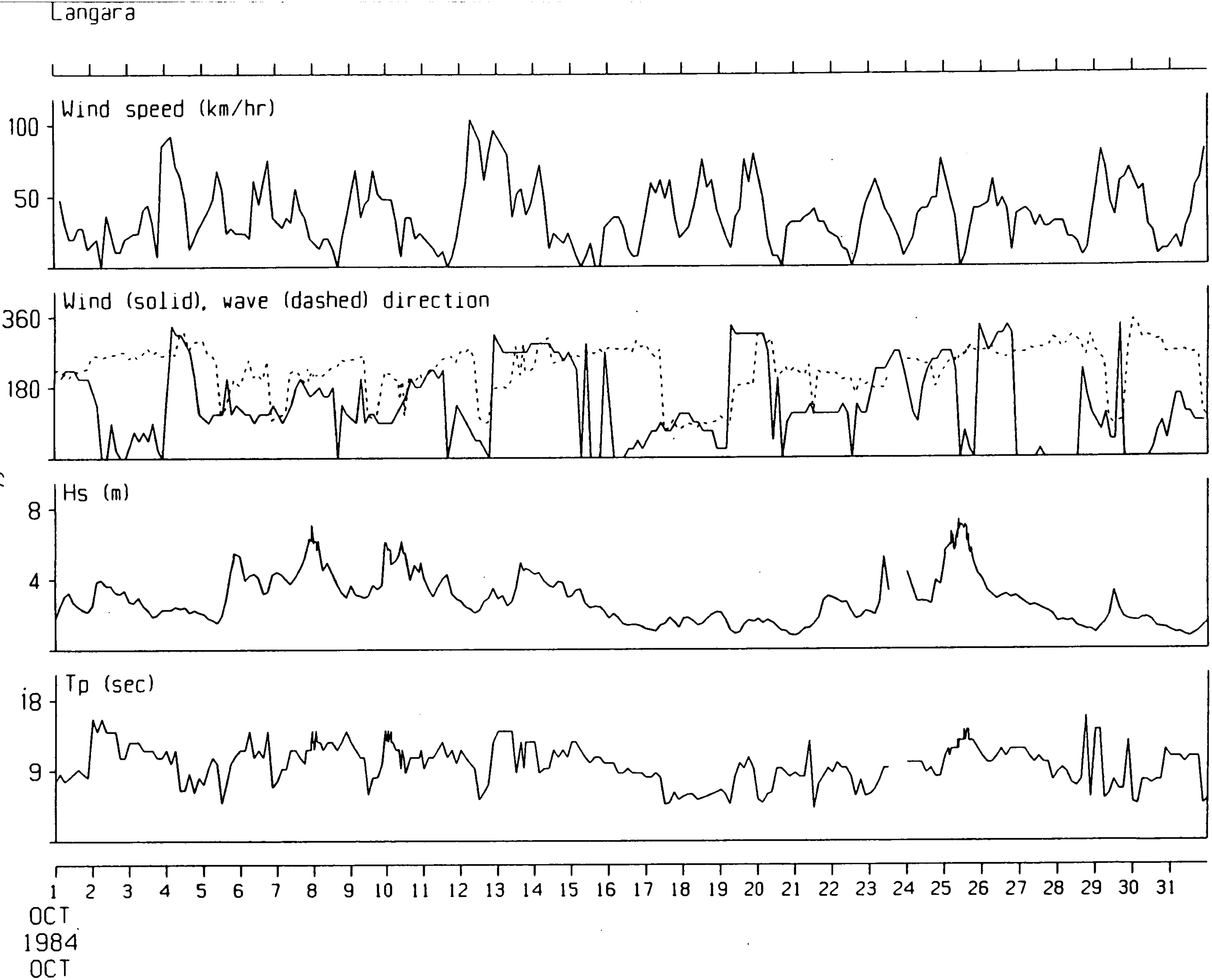

Langara
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1
JUN
1984
JUN
JUL

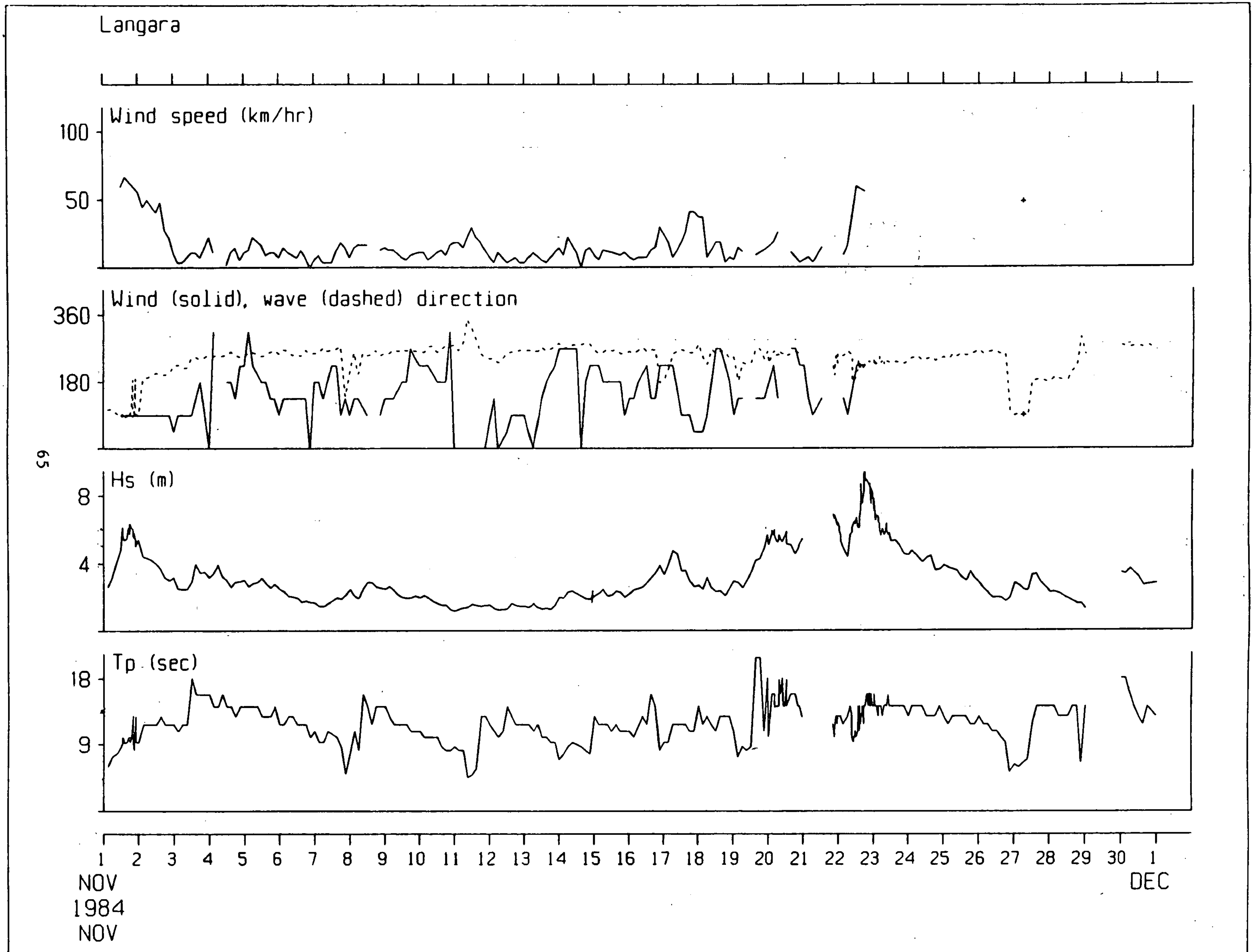


Langara
Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JUL
1984
JUL


Langara
Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AUG
1984
AUG


Langara
Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1
SEP
1984
SEP
OCT


Langara
Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
OCT
1984
OCT


Langara
Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
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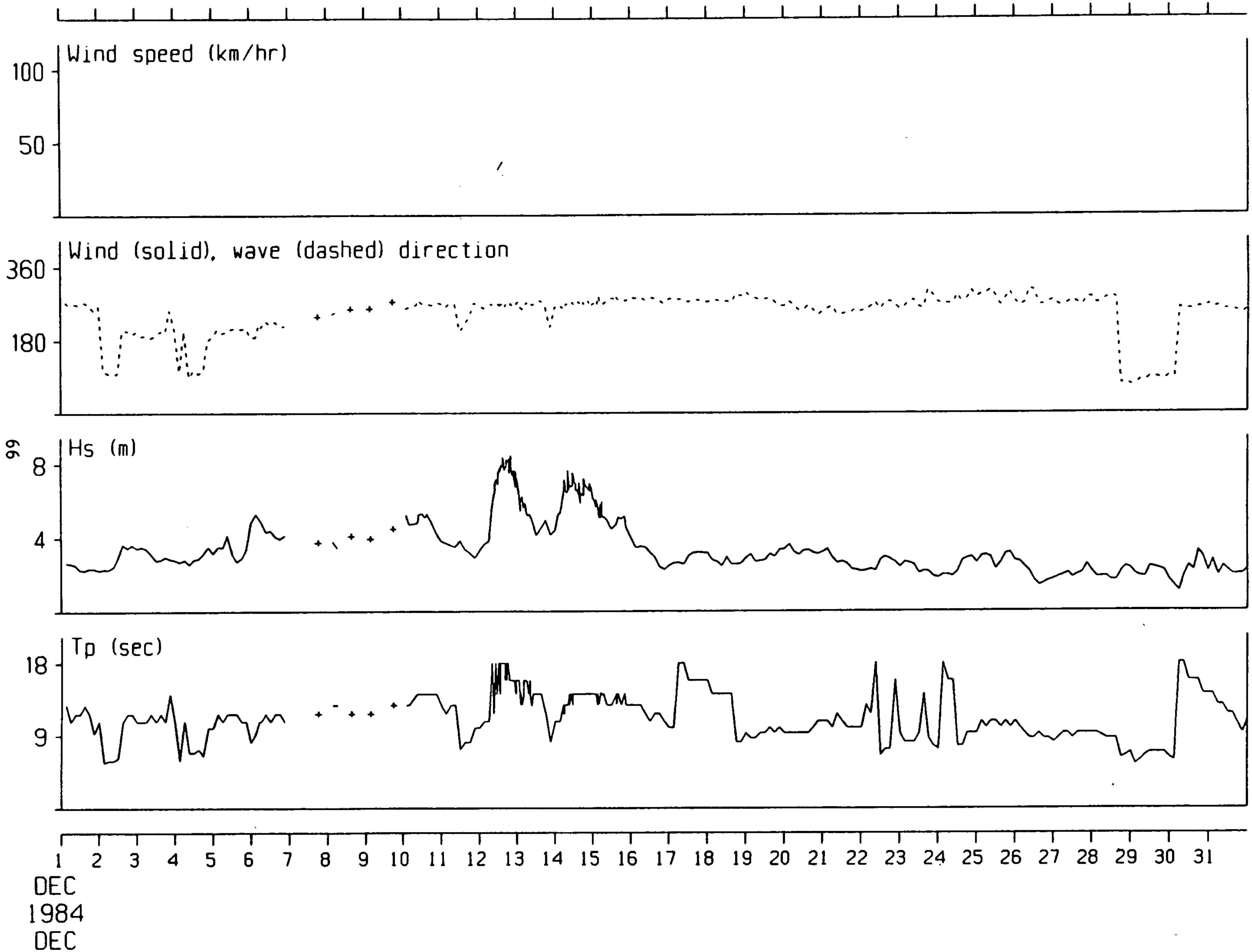
NOV
1984
NOV
DEC

Langara



Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
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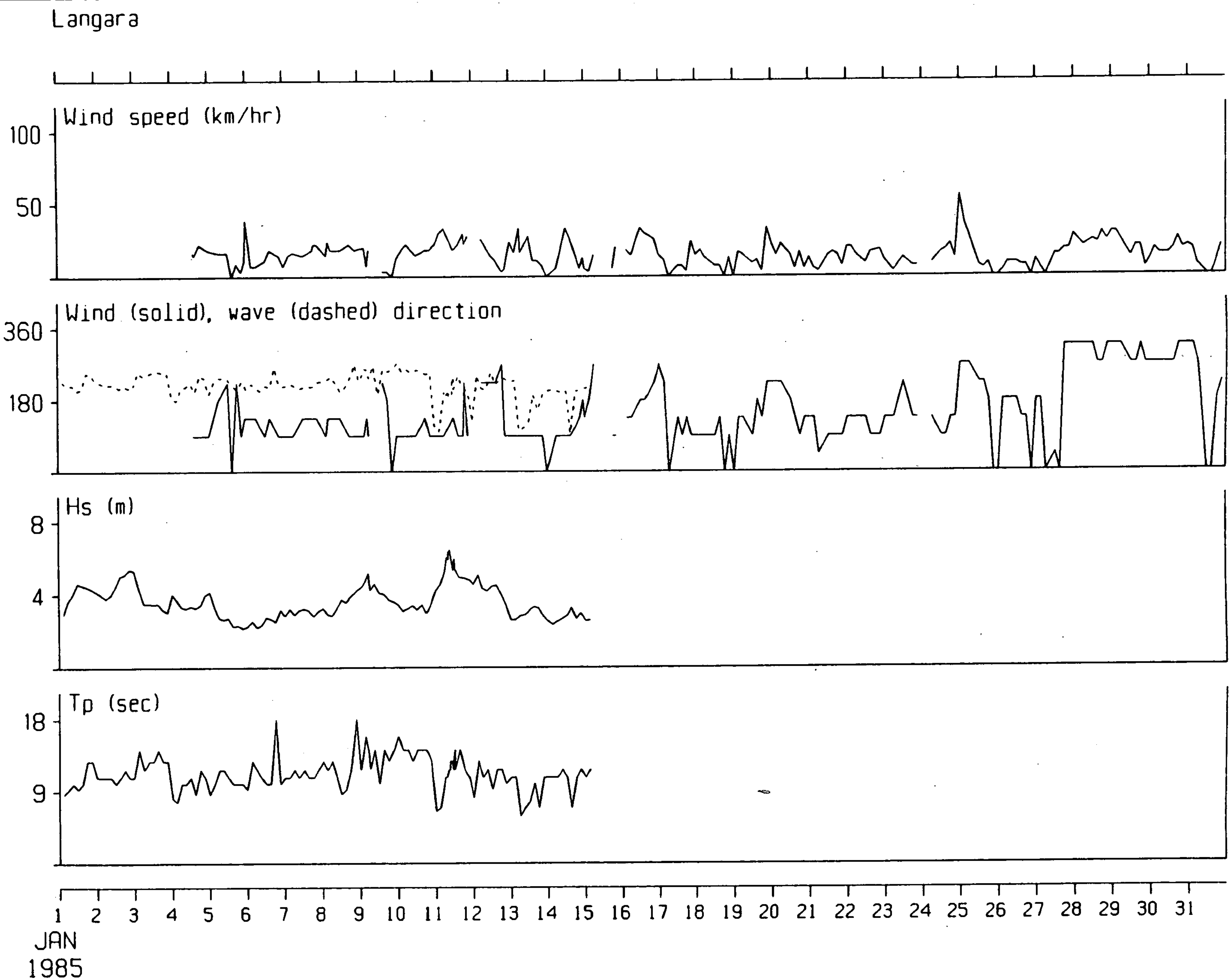
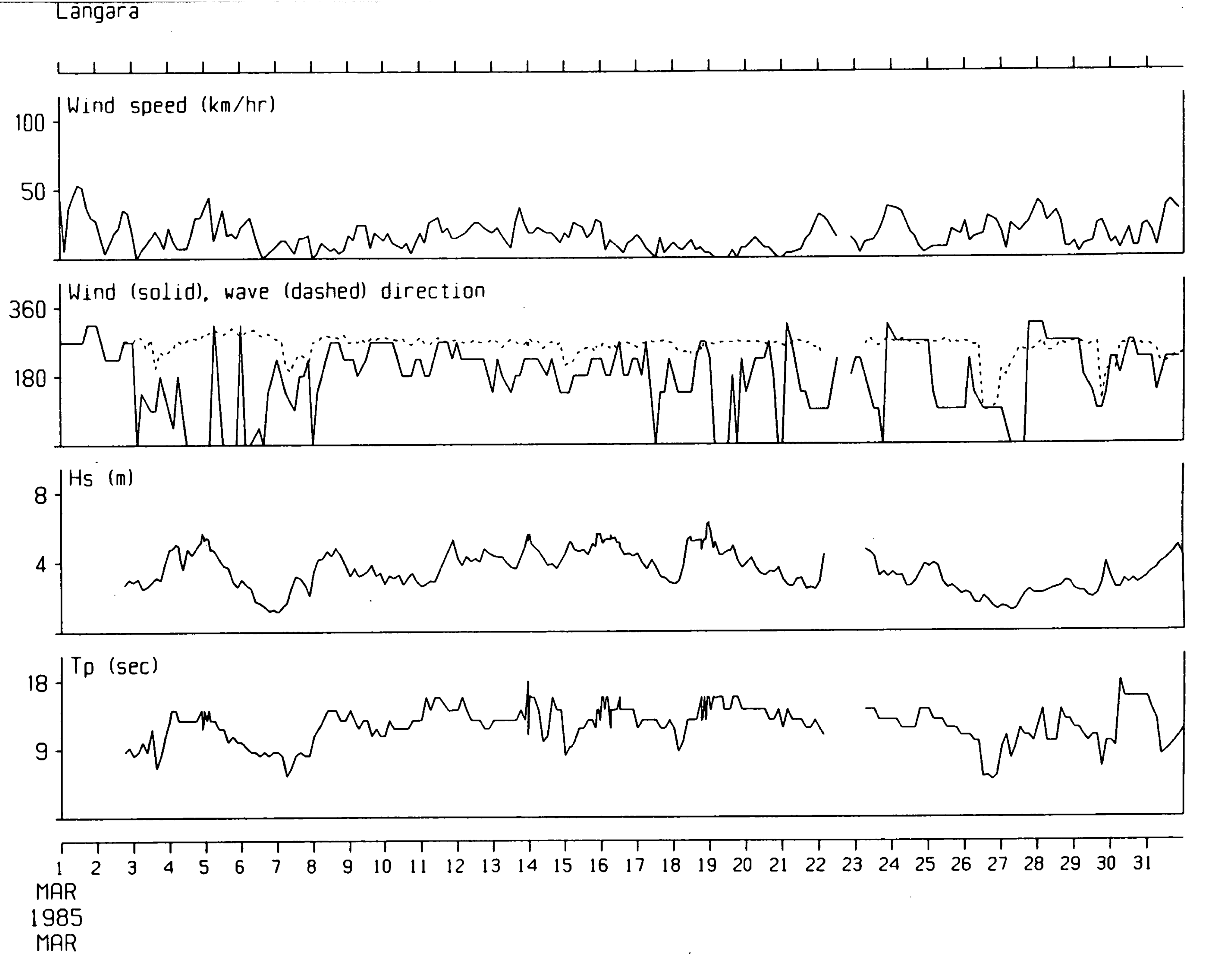
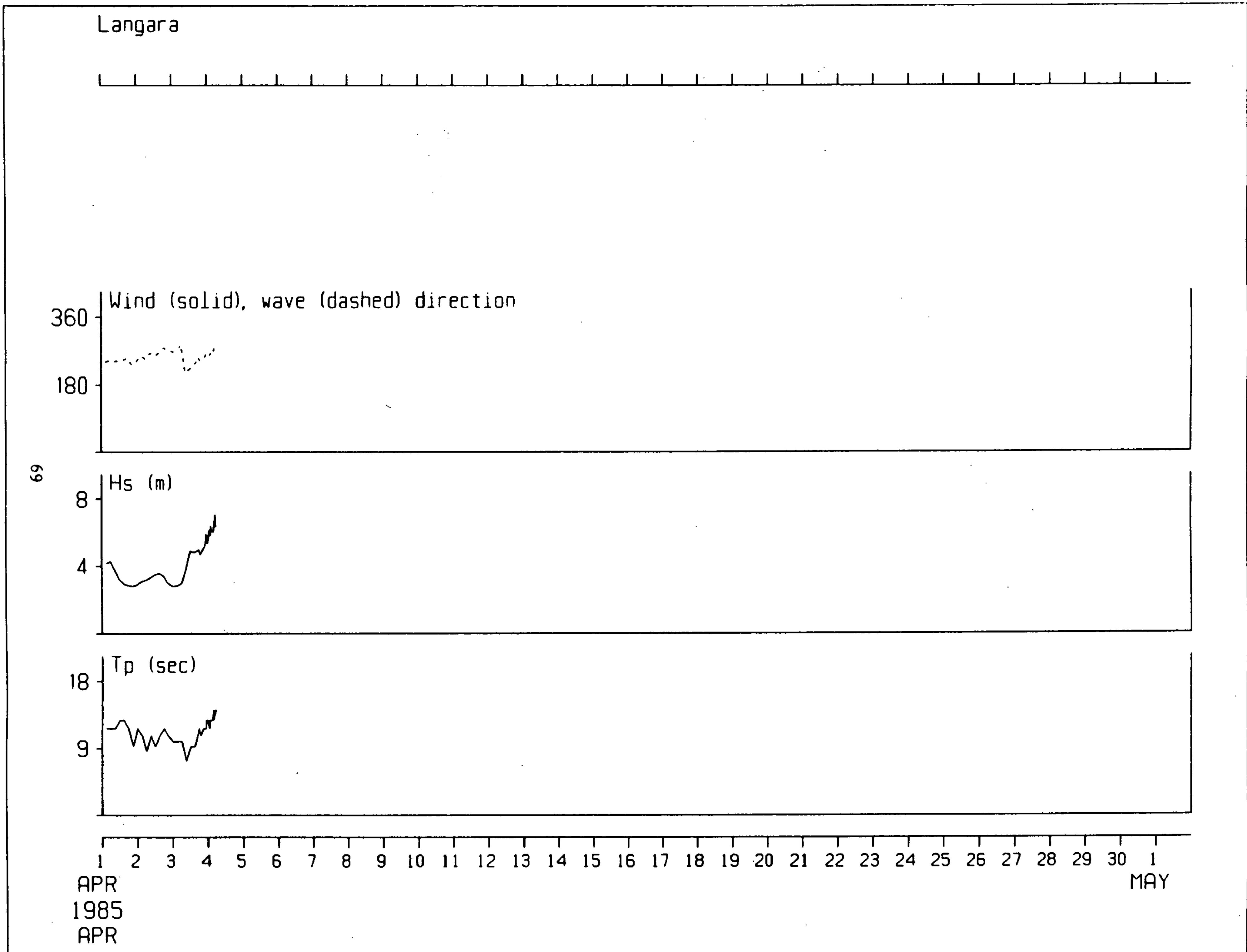
DEC
1984
DEC


Langara
Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
JAN
1985

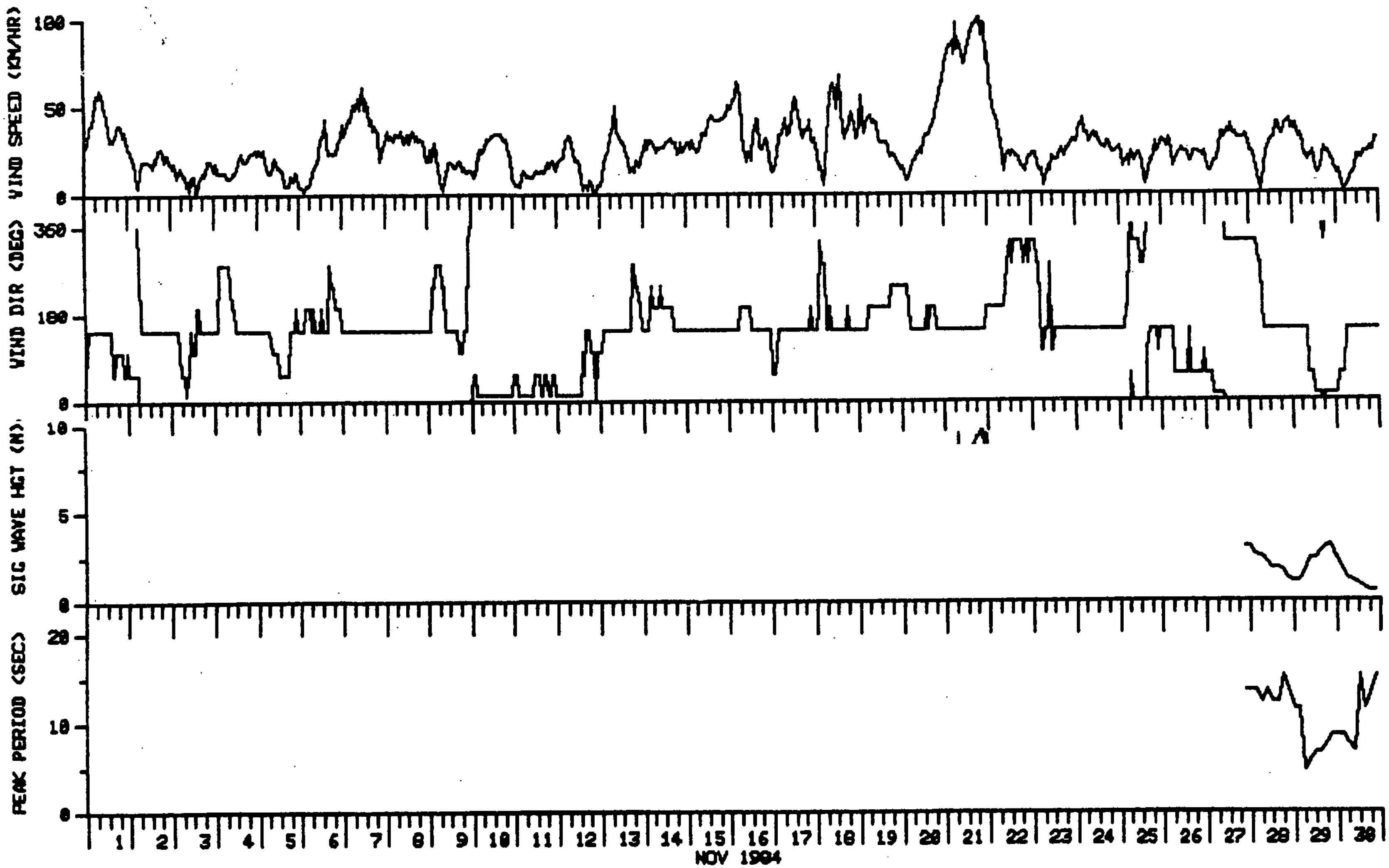

Langara
Wind speed (km/hr)
100
50
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MAR
1985
MAR



Langara
Wind (solid), wave (dashed) direction
360
180
Hs (m)
8
4
Tp (sec)
18
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1
APR
1985
APR
MAY

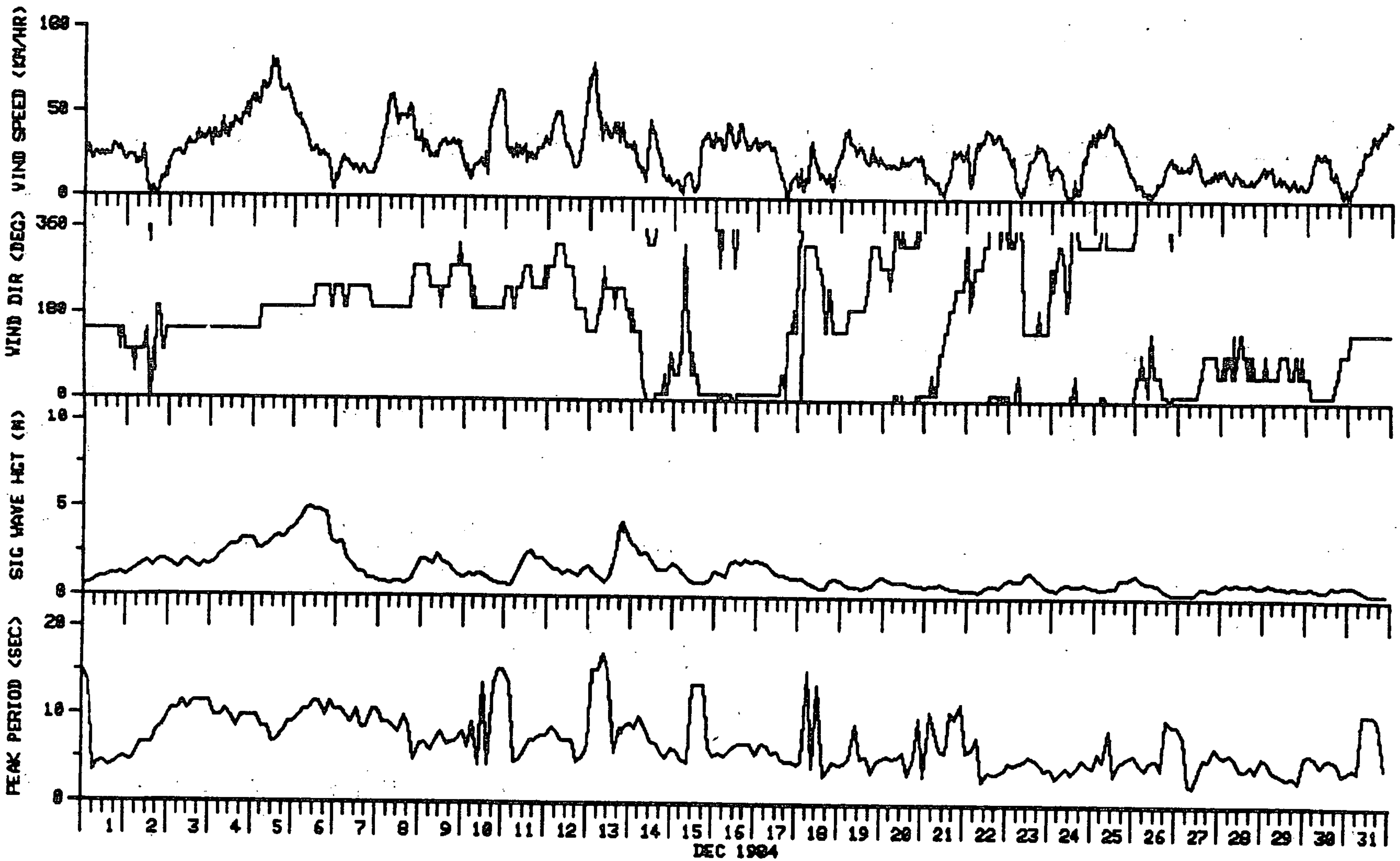
STATION 213
BONILLA ISLAND WIND DATA

BONILLA ISLAND



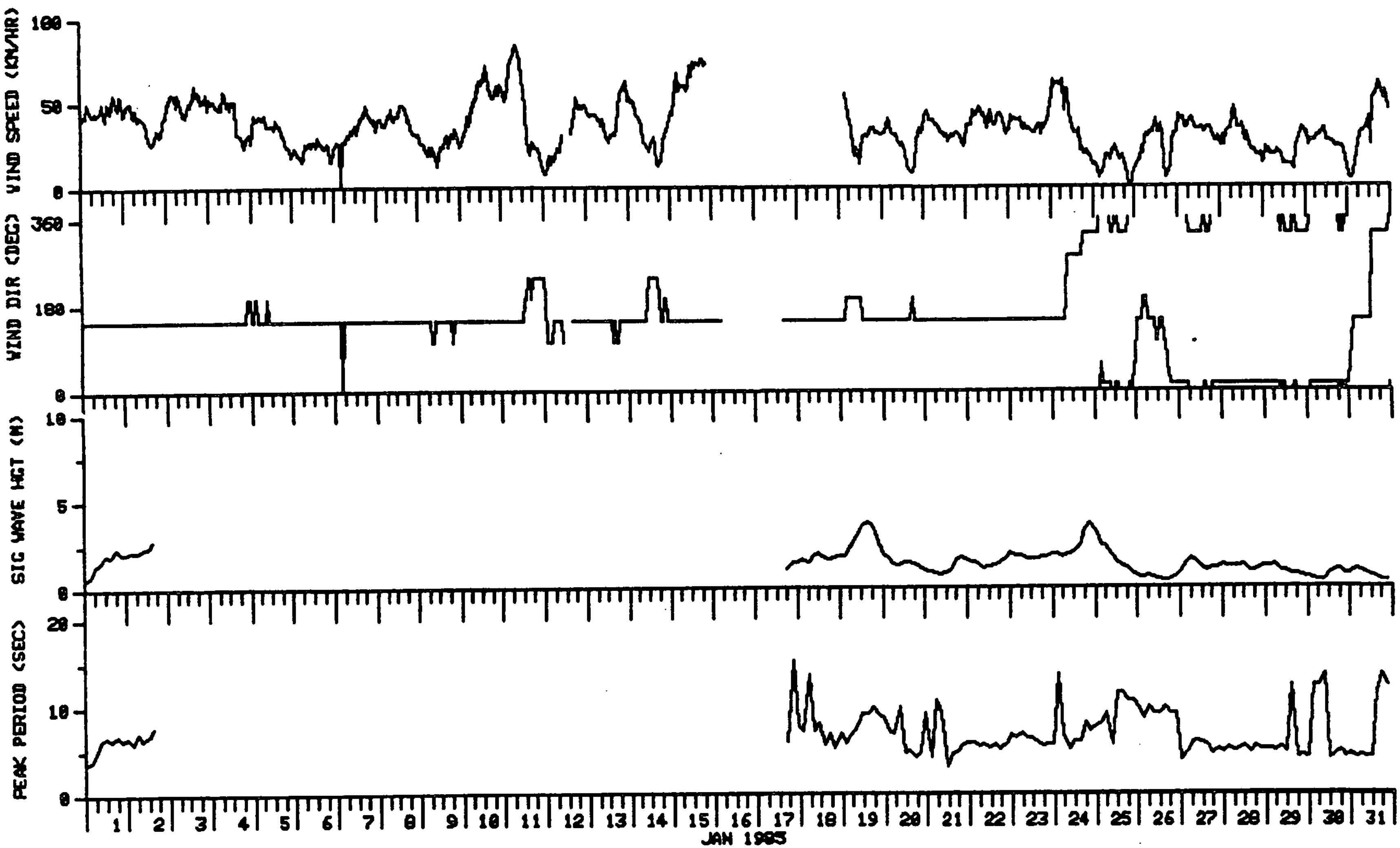
STATION 213
BONILLA ISLAND WIND DATA

BONILLA ISLAND



STATION 213 BONILLA ISLAND

BONILLA ISLAND WIND DATA



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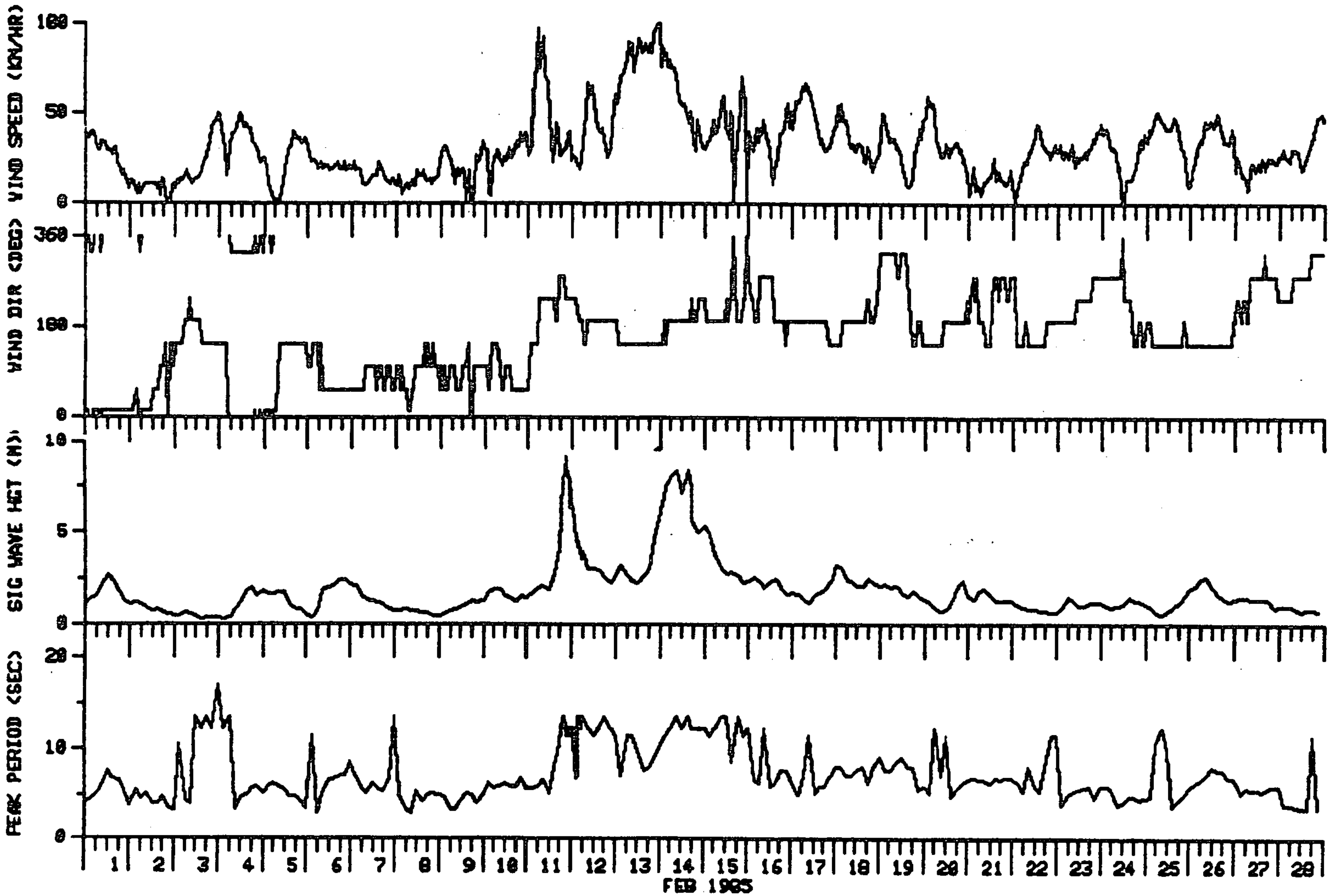
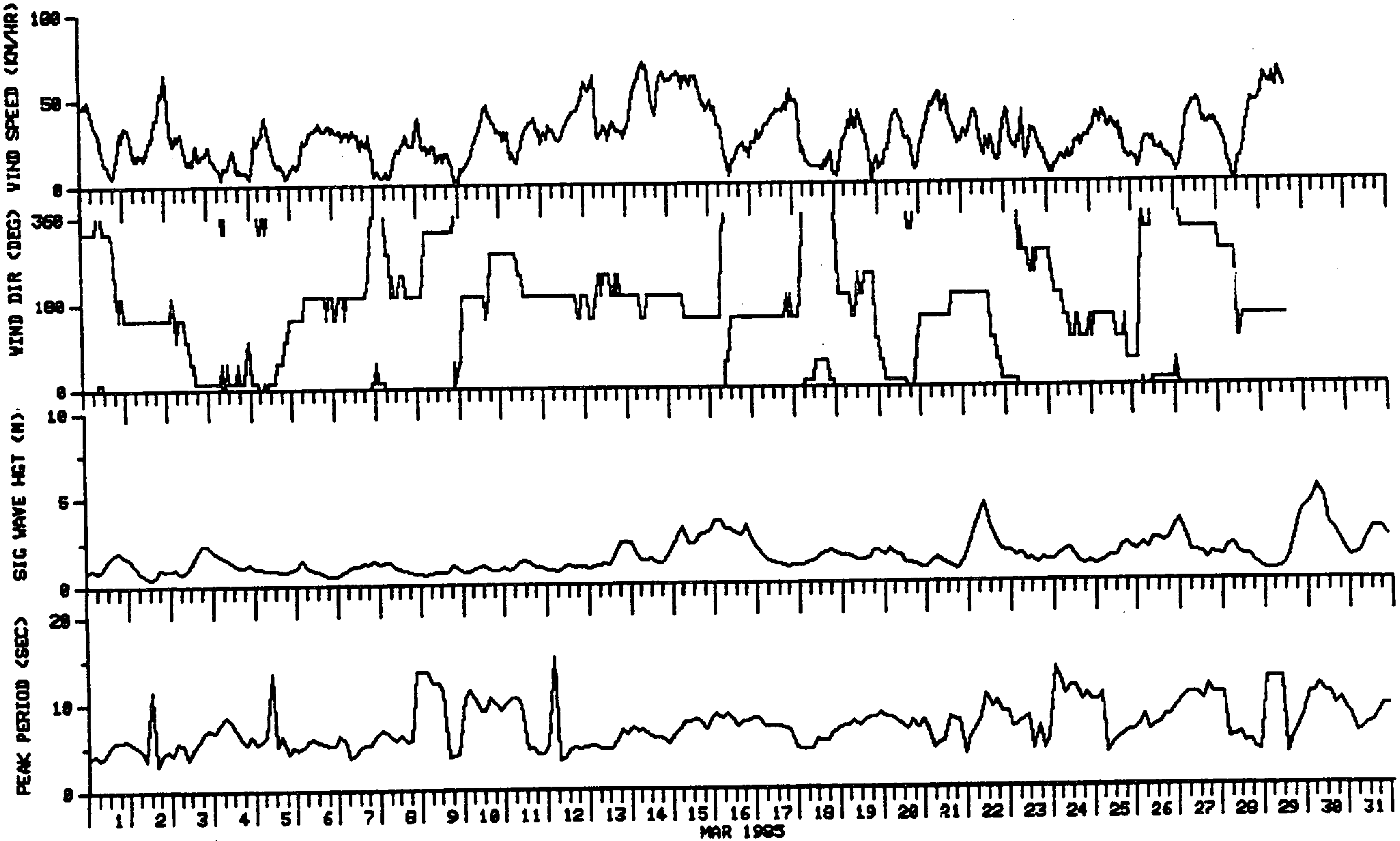
BONILLA ISLAND WIND DATA

BONILLA ISLAND



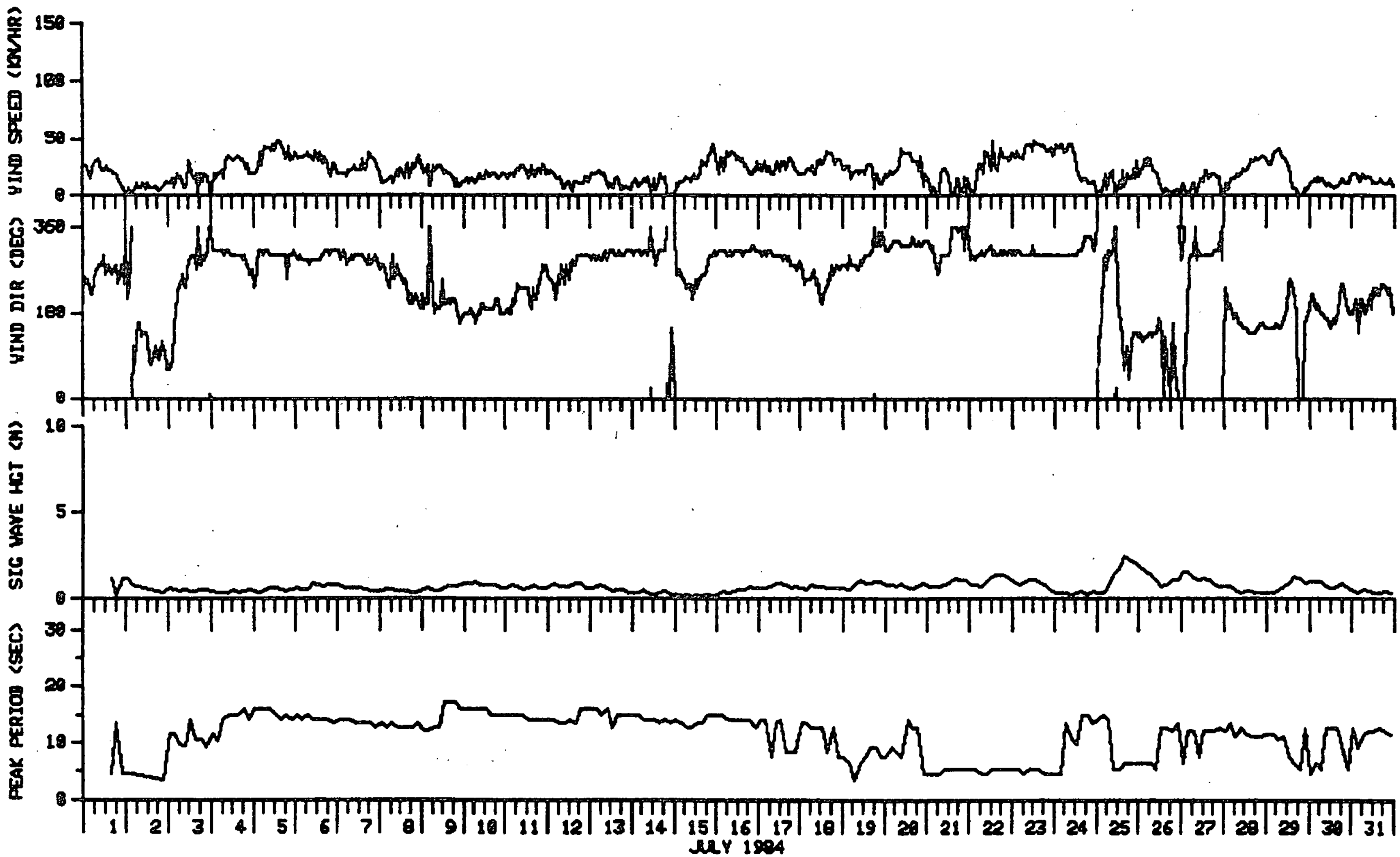
STATION 213
BONILLA ISLAND WIND DATA

BONILLA ISLAND



STATION 215
CAPE ST. JAMES WIND DATA

HECATE STRAIT



STATION 215 HECATE STRAIT

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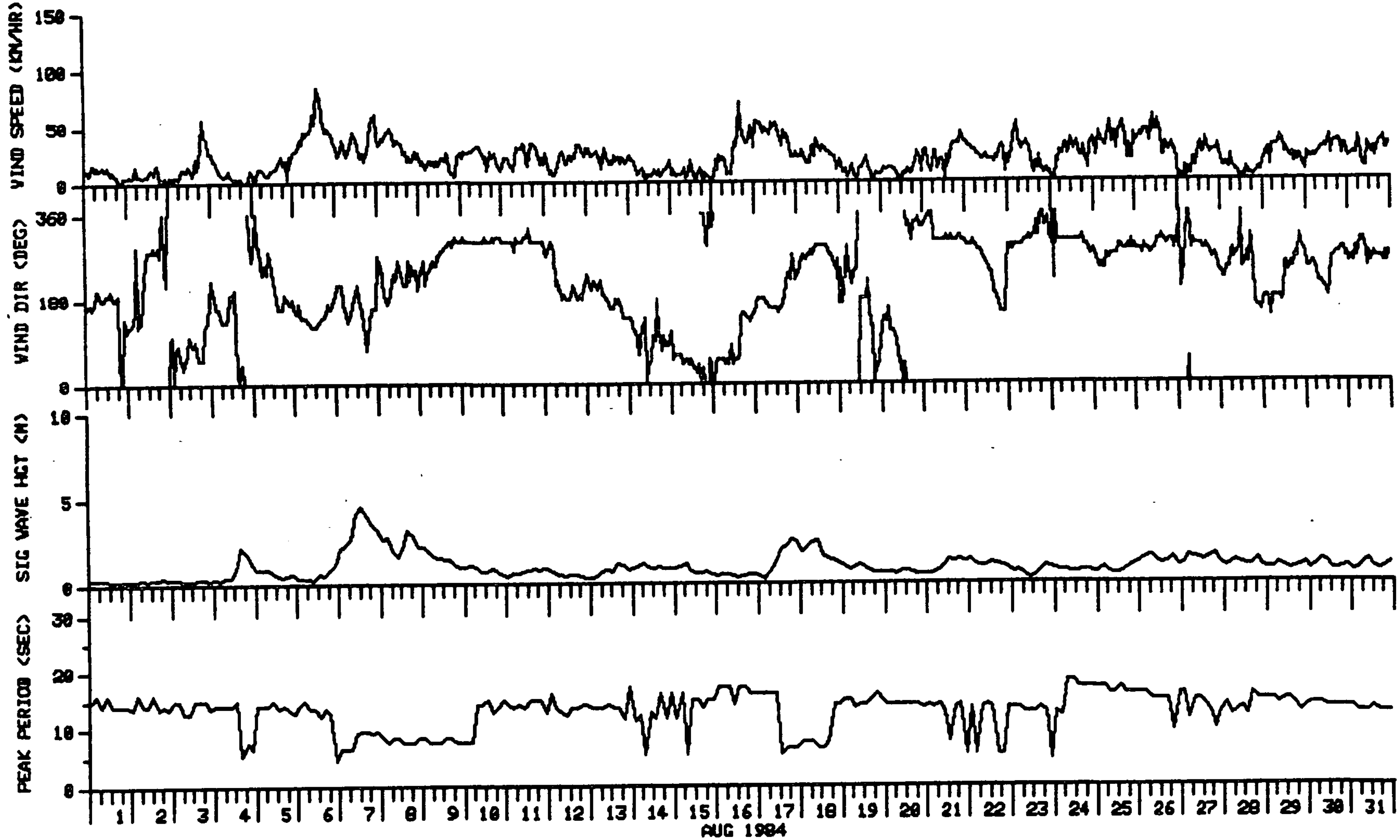

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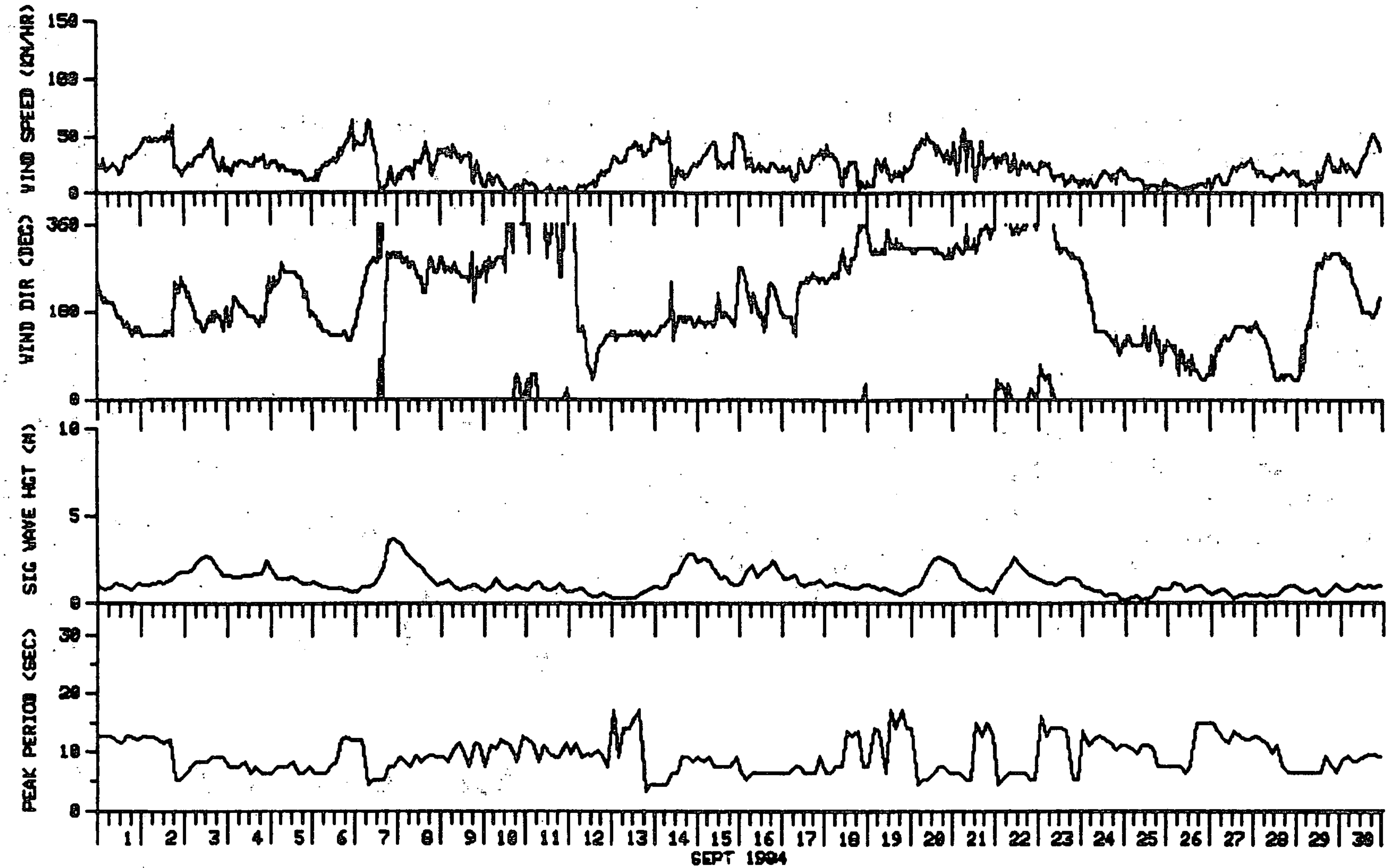

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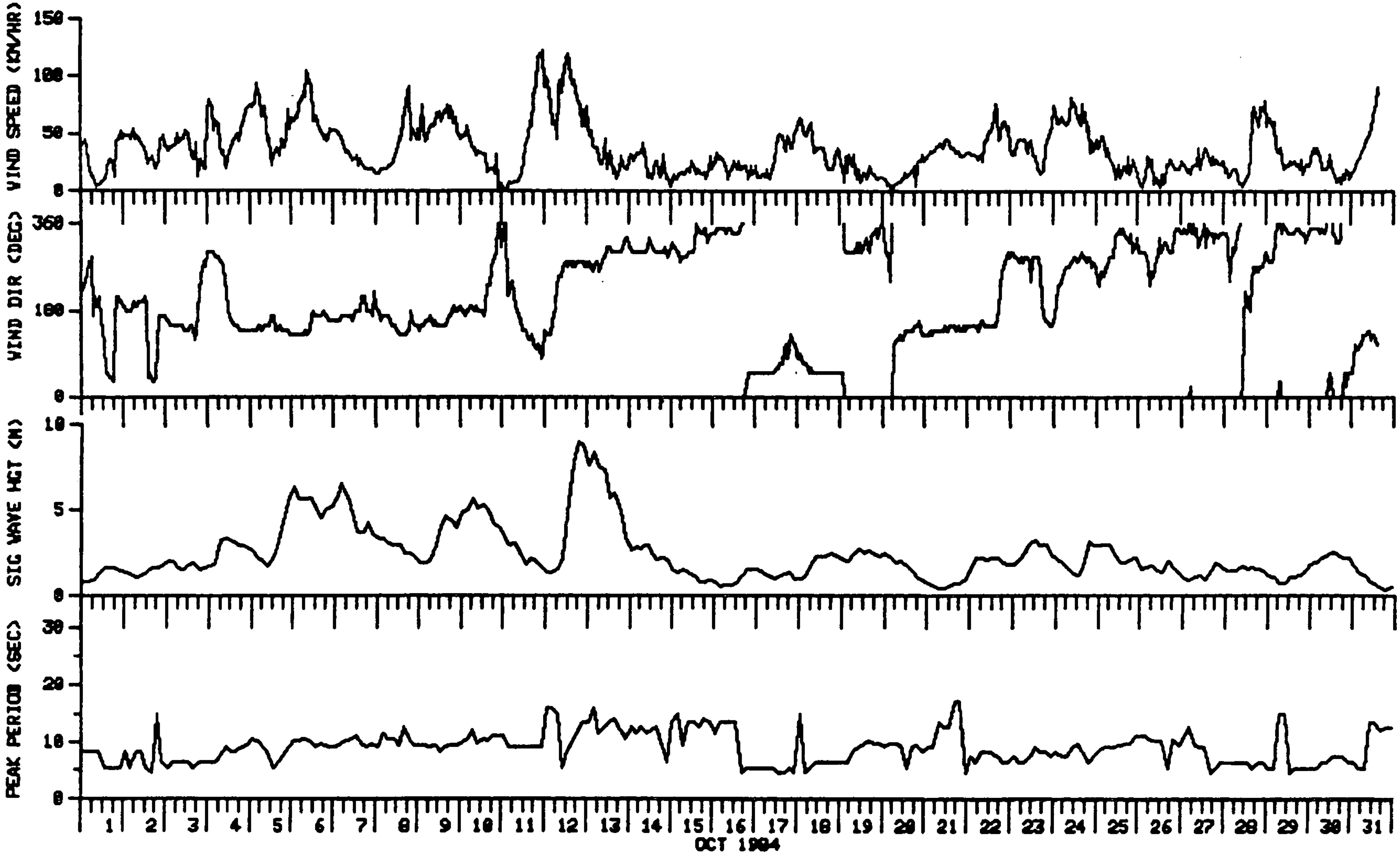

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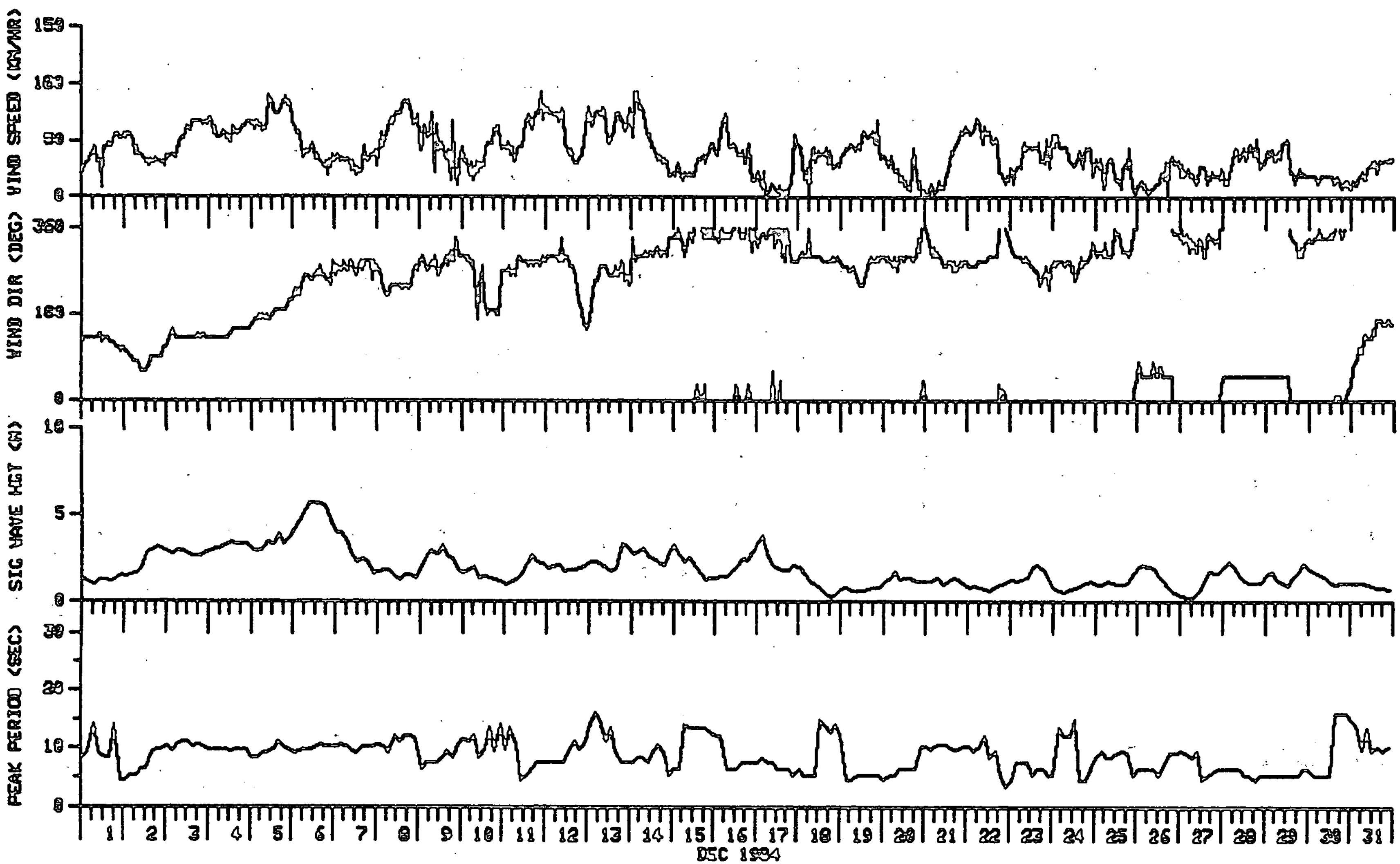

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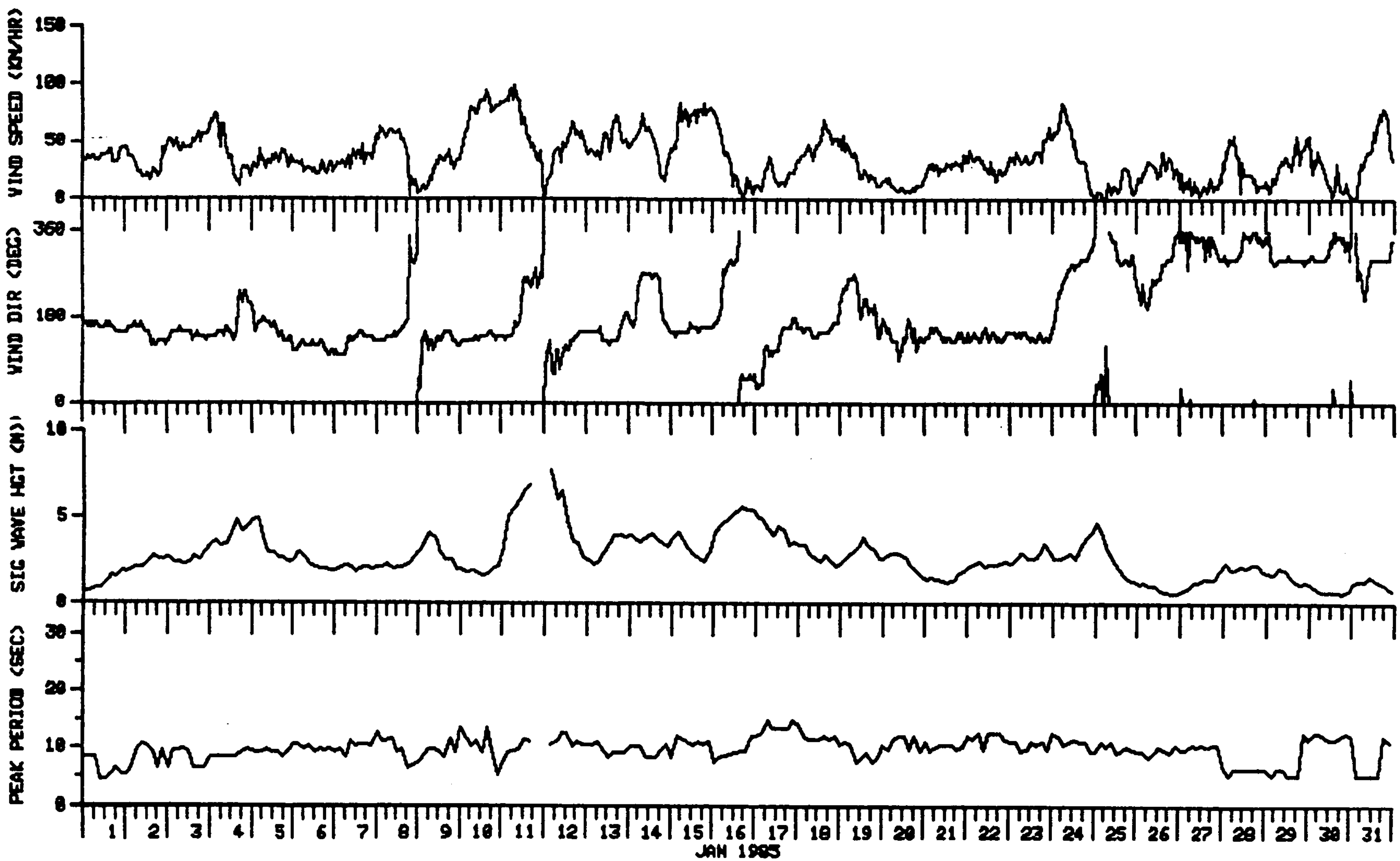

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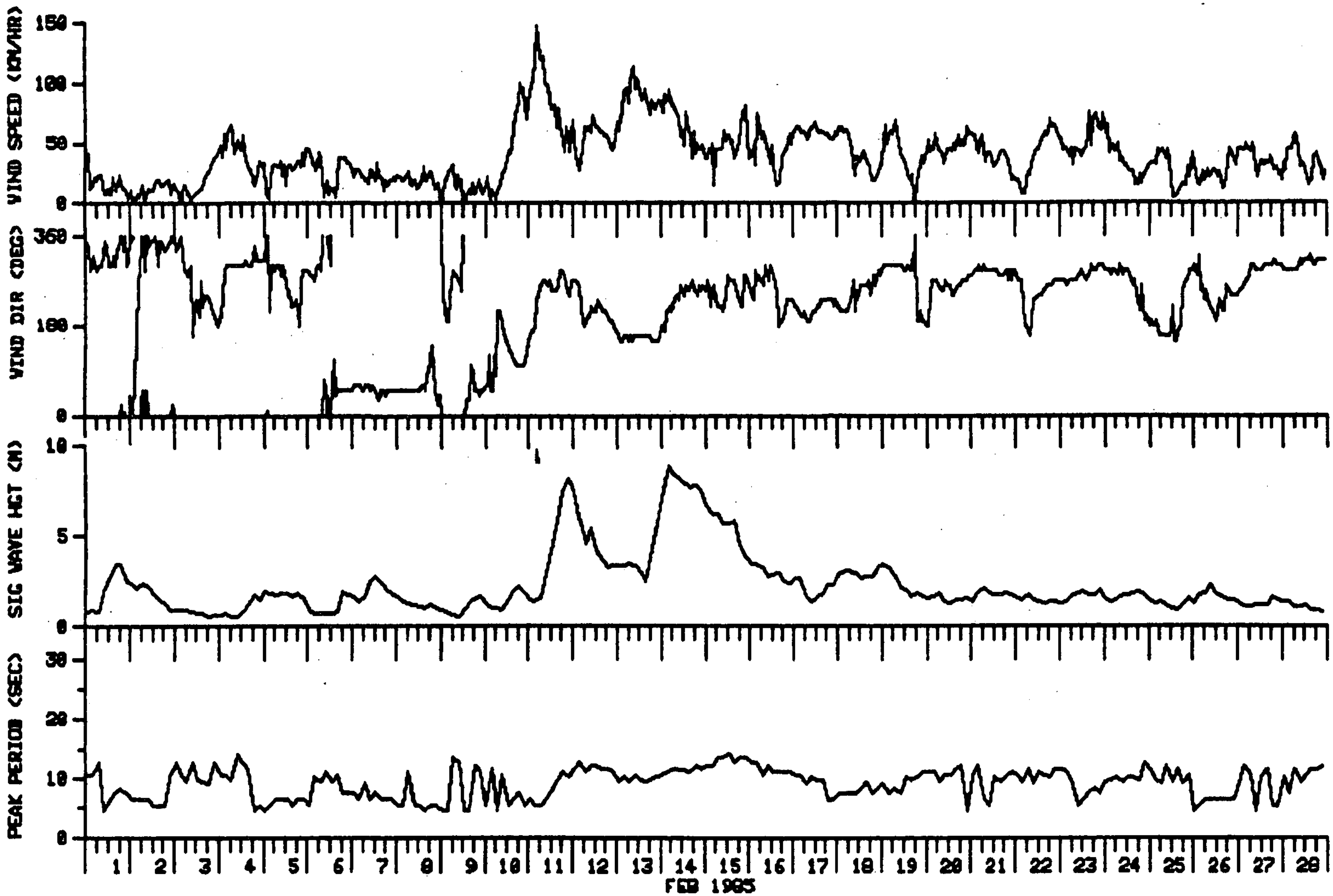

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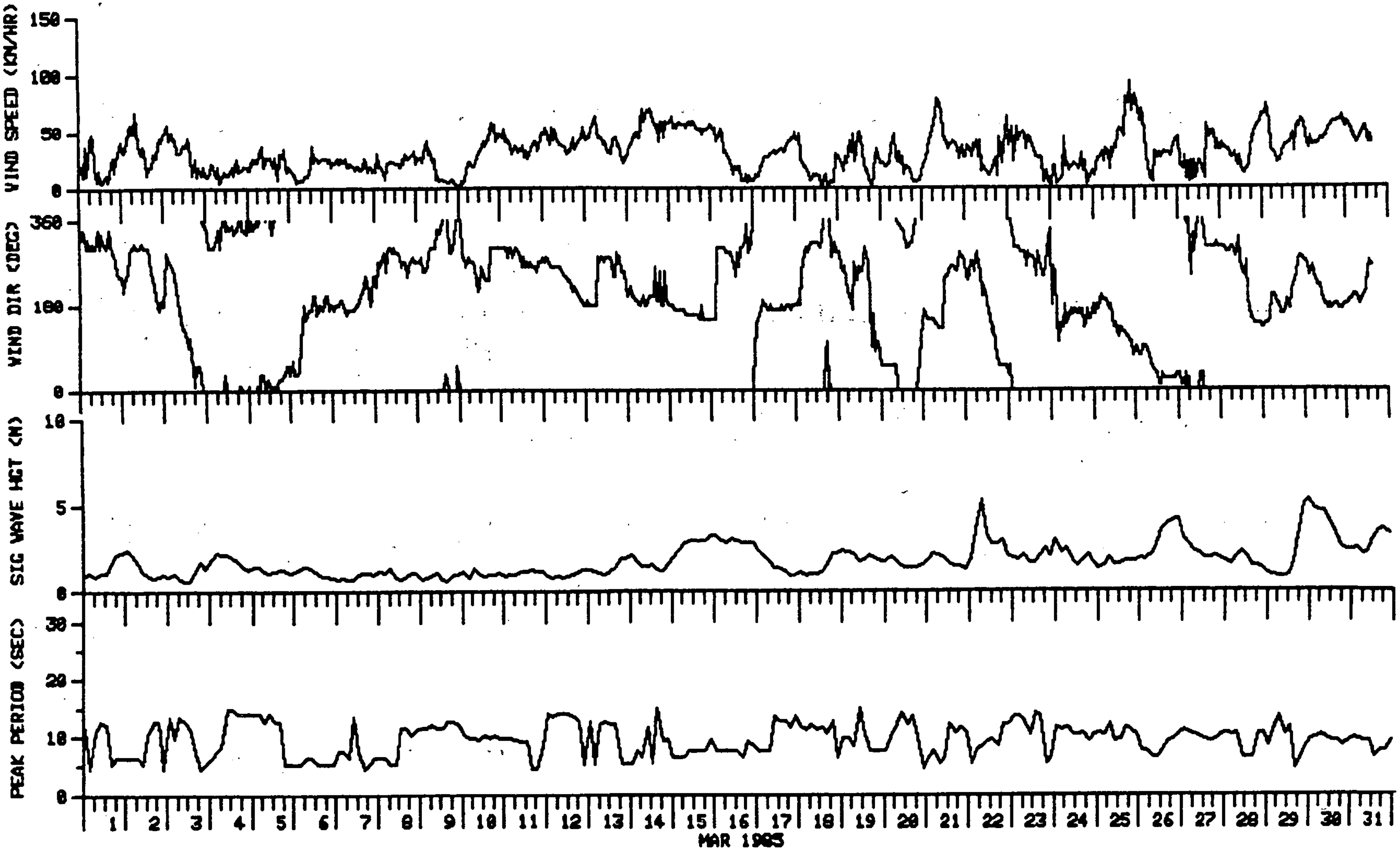
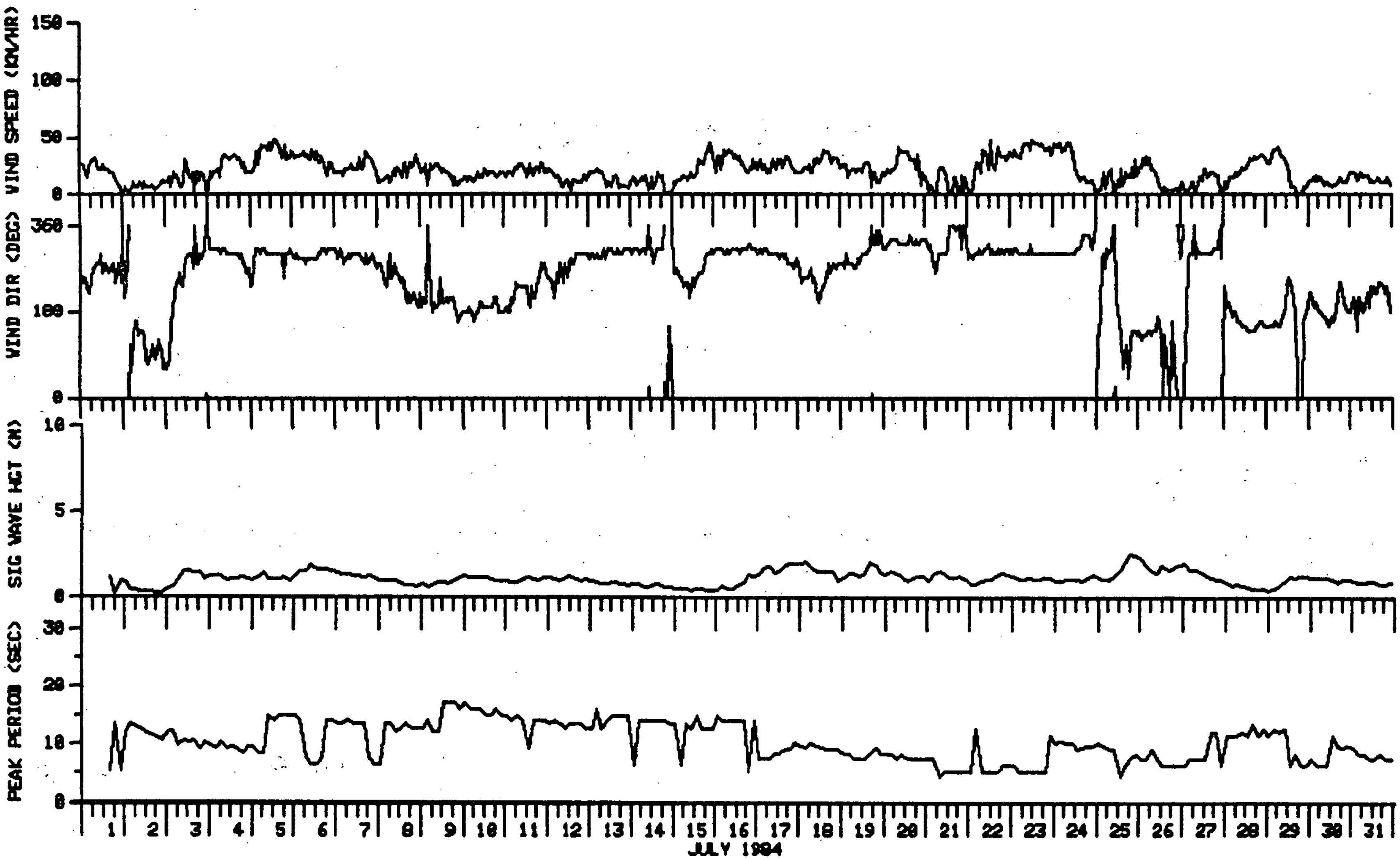


STATION 216

CAPE ST. JAMES WIND DATA

QUEEN CHARLOTTE SOUND



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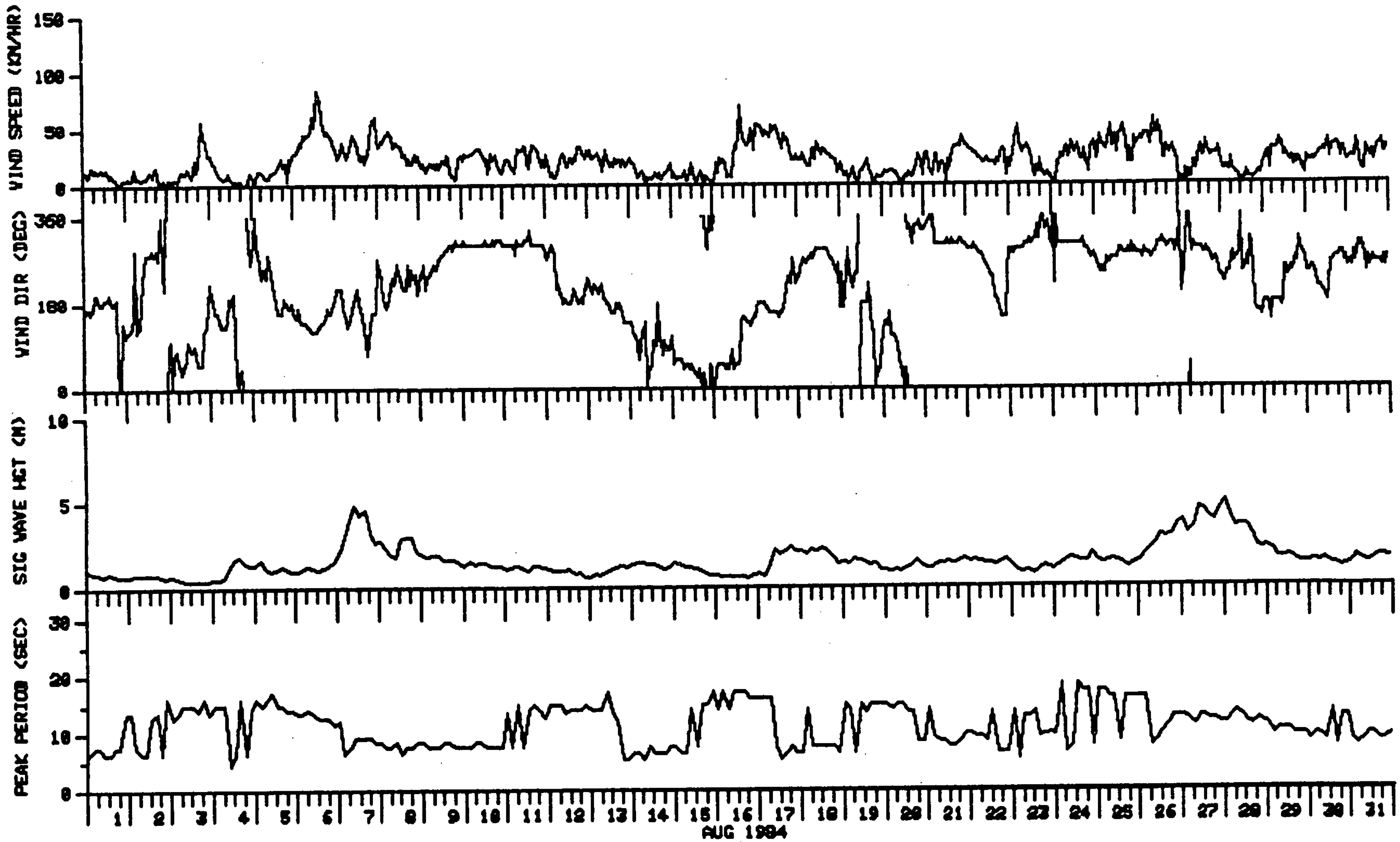

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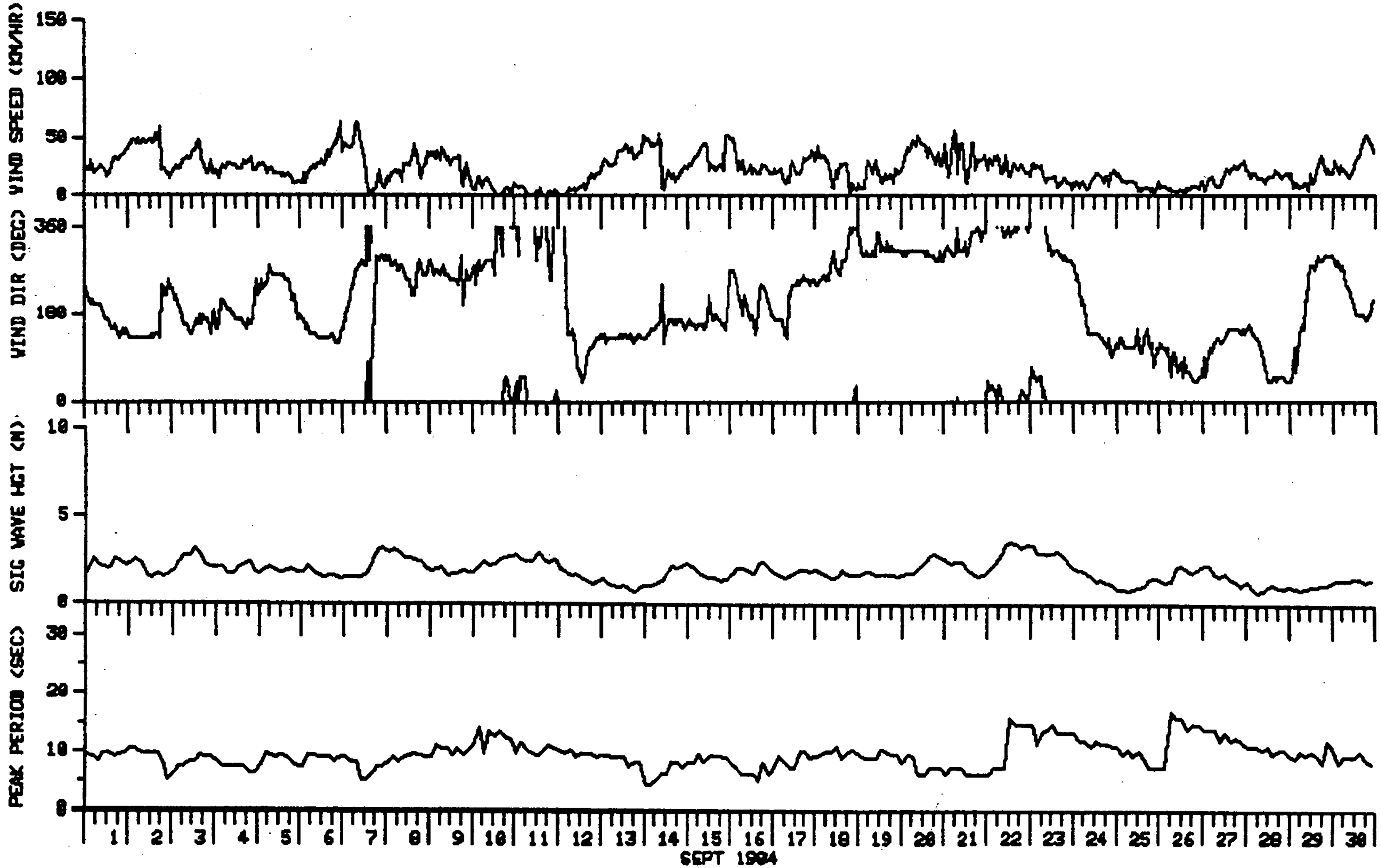
QUEEN CHARLOTTE SOUND



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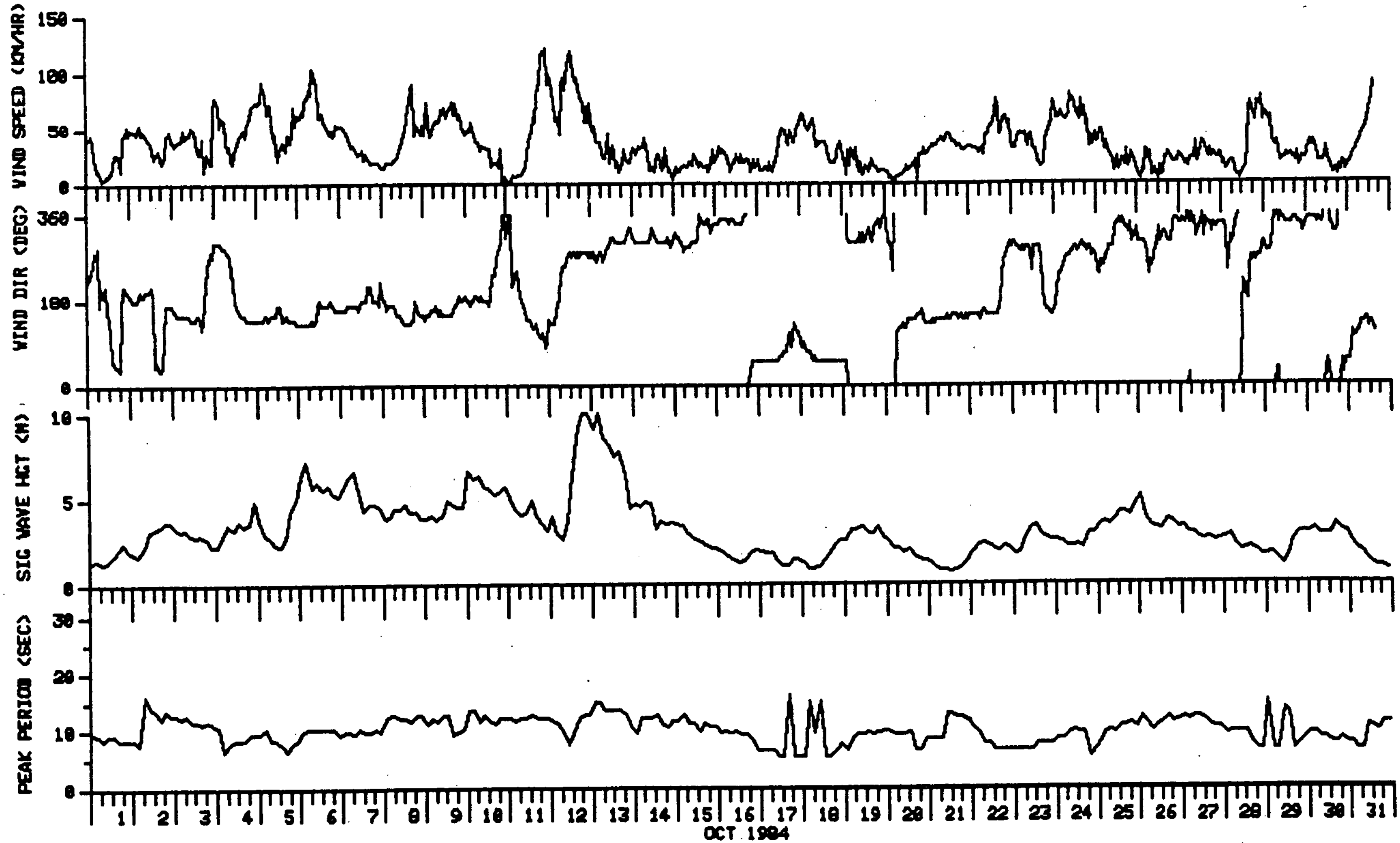

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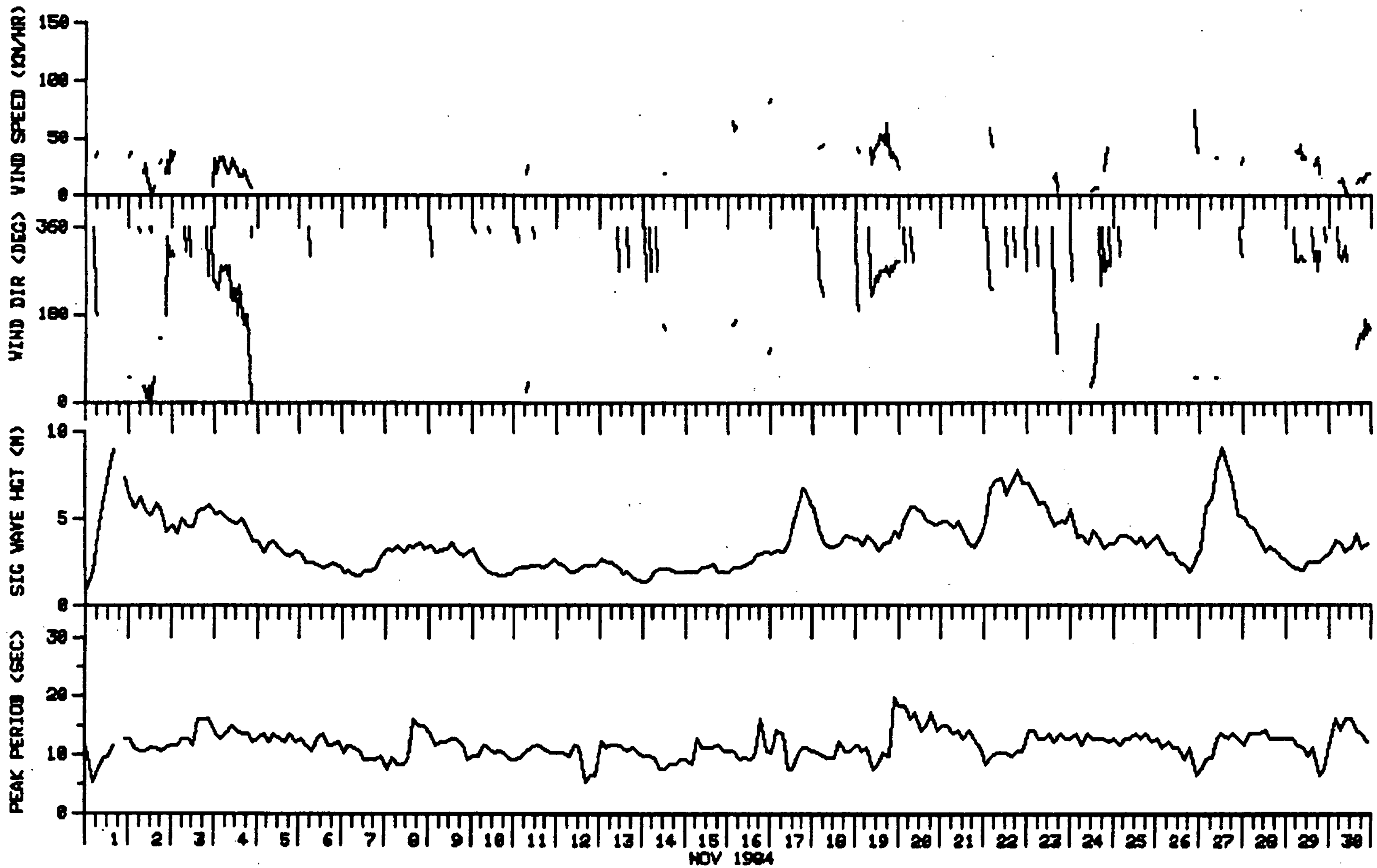

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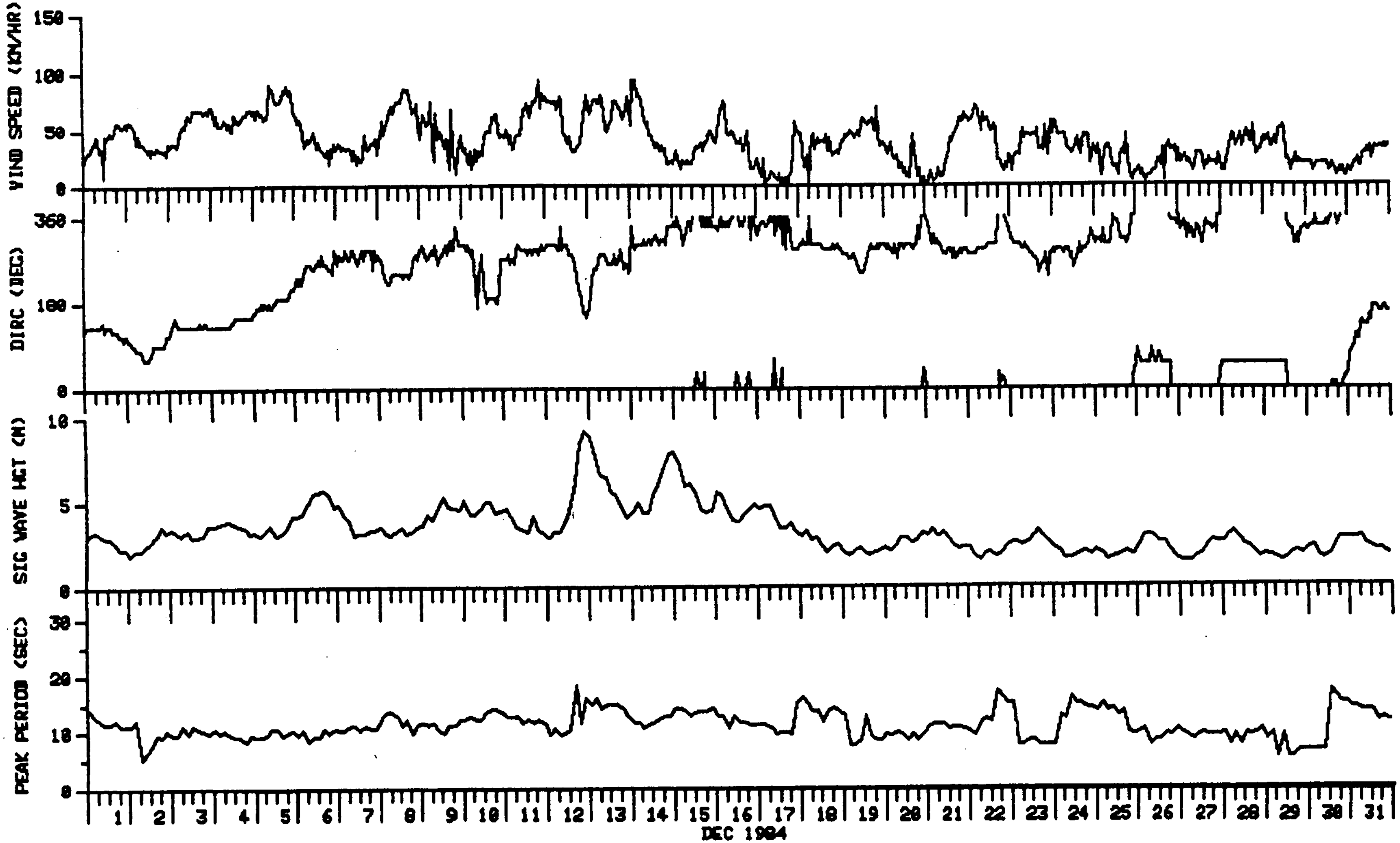
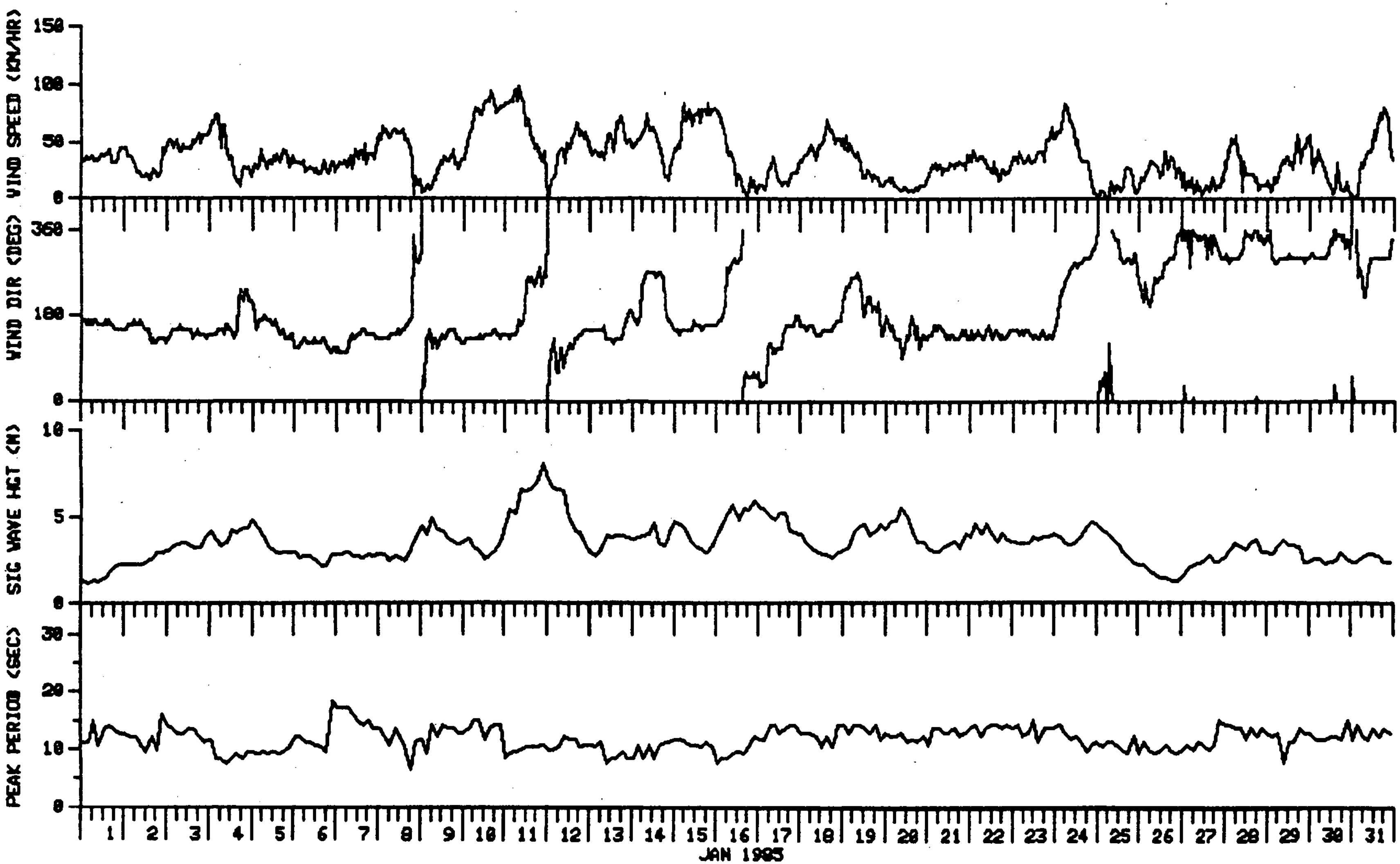


88

STATION 216 QUEEN CHARLOTTE SOUND

CAPE ST. JAMES WIND DATA



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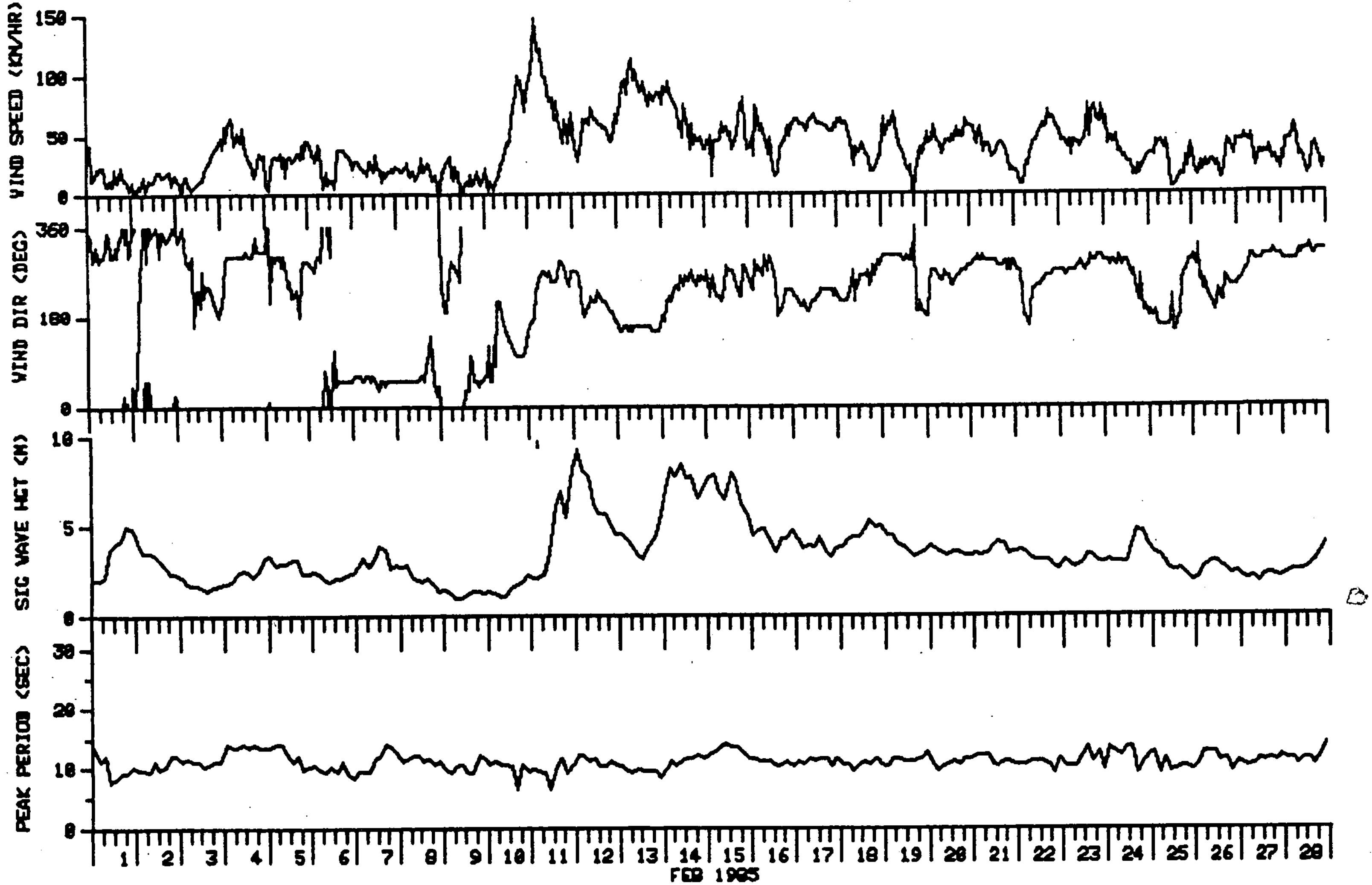
QUEEN CHARLOTTE SOUND



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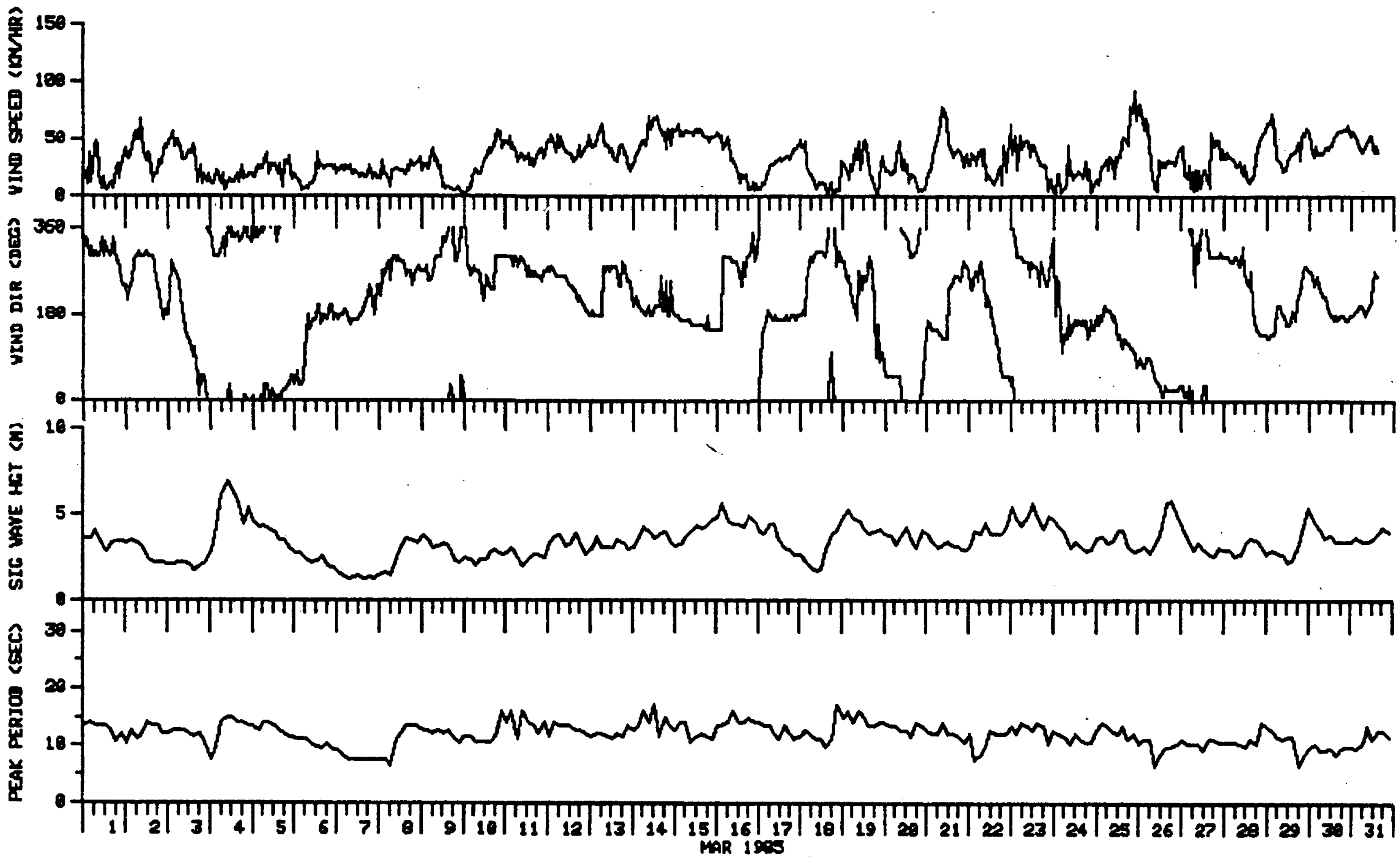

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