SPOT X

Summary of Metocean Conditions

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1. INTRODUCTION

An analysis of wave, wind and surface currents has been carried out to characterise the metocean conditions at a site in the South Atlantic with location 49°40´S 59°W. The site is exposed to the prevailing mid-latitude weather systems and associated sea states. Partial sheltering from Southern Ocean swell is provided by Patagonia.

All data has been obtained from hindcast reanalyses, with wave data from a global wave hindcast carried out by MetOcean Solutions Ltd, and winds and currents from the NOAA Climate Forecast System Reanalysis. A period of 22 years from 1989-2010 has been utilised.

All statistics, in particular extreme value analyses, are intended to summarise the metocean conditions and are not intended for Basis of Design purposes.

All wind and wave data is presented as coming from in nautical degrees, while all current data is going to.

2. DATA SOURCES

2.1. Waves

Spectral wave parameters have been derived from a 22-year (1989-2010) hindcast, with data available at 3-hourly intervals. The wave hindcast was generated using the WW3 (WAVEWATCH III) model on a global grid with a resolution of 0.5° by 0.5° (approximately 50 km by 50 km).

The winds used for the WW3 hindcast were from the CCMP dataset (Atlas et al., 1996; data distributed by NASA). The Tolman/Chalikov physics options were used. Available satellite observations of wave height from the Topex/Poseidon and Jason satellite altimeters were assimilated, with calibration using the formulas of Queffeulou (2004).

2.1.1. Validation

No site specific validation has been carried out, and to our knowledge data is not currently available. However, a general validation of the regional wave hindcast was carried out to verify that the wave climate was appropriately reproduced. Significant wave height estimates from the Topex/Poseidon and Jason satellite altimeters were co-located and compared for the years 2000-2010 over a 1° by 1° area centred on the location of interest. At total 13404 collocated data pairs were obtained. No filtering of either data set has been carried out.

Quantitative measures of accuracy are calculated from the measured, x_m and hindcast, x_h , data. These are defined as:

Mean absolute error (MAE): $\overline{|x_h - x_m|}$ (2.1)

RMS error (RMSE): $\sqrt{\overline{(x_h - x_m)^2}}$ (2.2)

Mean relative absolute error (MRAE): $\overline{\left|\frac{x_h - x_m}{x_m}\right|}$ (2.3)

Bias: $\overline{x_h - x_m}$ (2.4)

Scatter Index (SI): $\frac{\sqrt{\overline{(x_h - x_m)^2}}}{\overline{x_h}}$ (2.5)

Plots of collocated measured and hindcast data are shown in Figure 2.1 while the accuracy measures are presented in Table 2.1. The hindcast is biased low by 0.26 m; the quantile plot indicates that this bias is distributes fairly evenly throughout the observed wave height range. Note that no very high energy events over 5 m significant wave height are present in the data.

Other than the bias, the relative error and scatter index are quite reasonable, indicating that the hindcast has reproduced the general conditions well. No bias correction was applied to the hindcast wave statistics.

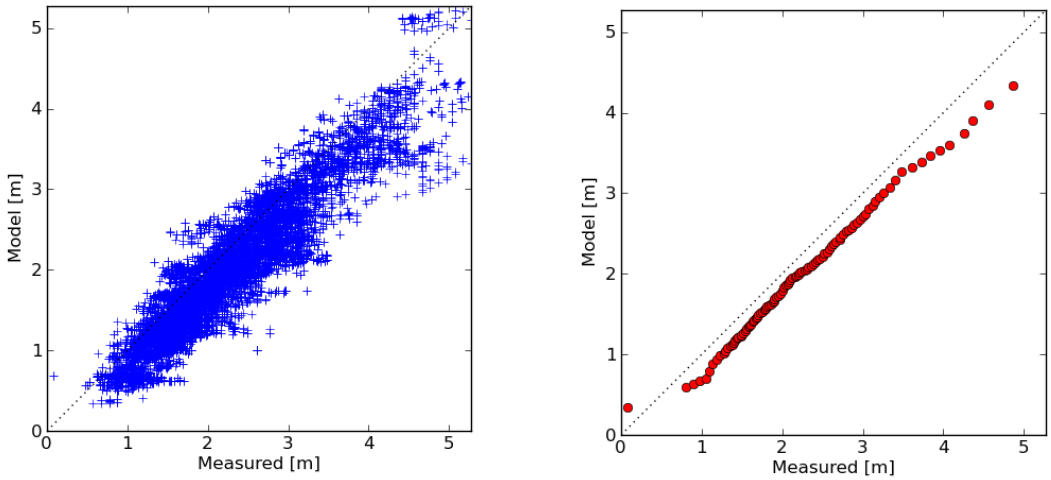

Figure 2.1 Collocated satellite estimates of significant wave height with hindcast values shown as coincident values (left) and quantile-quantile plot (right).

Table 2.1 Accuracy measures of hindcast from comparison with satellite estimates of significant wave height.

MAE [m]	0.34
RMSE [m]	0.44
MRAE [%]	0.15
Bias [m]	-0.26
SI	0.19

2.2. Winds

Winds were extracted from the Climate Forecast System Reanalysis (CFSR) from the National Centers for Environmental Prediction (NCEP) at NOAA (Saha et al. 2010). These data are 10 m elevation wind velocity vectors in a 1-hourly gridded format at a resolution of approximately 0.3° of longitude and latitude.

2.3. Currents

Currents were also extracted the CFSR dataset at 6 hourly intervals. The gridded resolution of the currents are 0.5°, which captures the dominant ocean flows, but does not resolve meso-scale features. The current data has not been validated for the location of interest, and is only appropriate for a general indication of ambient condtions.

3. ANALYSIS METHODS

3.1. Spectral partitioning

The hindcast wave spectra were partitioned using the method described in Tracy et al. (2007), and as implemented in WaveWatch3 (Tolman, 2009). The partitioning method follows a watershed algorithm that separates the spectral surface into a set of discrete peaks.

The 'sea' component is defined being actively driven by the wind. This is identified as any partition for which W>0.3333 where:

$$W = E_p^{-1}[E_p]_{U_c > C}$$
$$U_c = C_m U_{10} \cos(\theta - \theta_w) \qquad \text{(3.1a,b)}$$

where En is the total spectral energy in a partition, and $[E_n]_{U_p > C}$ is the total partition energy for which U_c is greater than the spectral component phase speed, C. The wave age factor C_m is set at 1.7 for 10 m windspeed U_{10}. The angles θ and θ_w are the wave and wind angle respectively. Where more than one sea partition is identified by the algorithm, these are merged into a single partition. Partitions not classified as sea are labelled as one or more swell components; the primary swell is defined to be that with the largest partial significant wave height. .

For each partition a one-dimensional spectrum is defined as:

$$S_n(f) = \int_{-\pi}^{\pi} E_n(f, \theta)\, d\theta \qquad \text{(3.2)}$$

and the peak frequency, f_p of the one-dimensional spectrum is identified. The significant wave height, H_s, mean direction at peak energy, θ_p and peak period, T_p are defined as:

$$H_s = 4\sqrt{\int_0^{\infty} S_n(f)\, df}$$
$$\theta_p = \arctan \frac{\int_{-\pi}^{\pi} E_n(f_p, \theta) \sin(\theta)\, d\theta}{\int_{-\pi}^{\pi} E_n(f_p, \theta) \cos(\theta)\, d\theta} \qquad \text{(3.3a,b,c)}$$
$$T_p = 1/f_p$$

The directional sectoring assigns the sea partition from each spectrum to one of the directional bins out using the values of θ_p

3.2. Return period values

Bivariate return period values (RPV) were calculated for significant wave height and peak period. The method of Repko et al. (2004) was employed, which considers the distribution of H_s and wave steepness, s. A joint PDF is calculated by multiplying marginal distributions of H_s and s (thus assuming they are independent), after which the PDF is transformed back into H_s / T_p space.

The marginal distributions for H_s and s are estimated by fitting the peaks over threshold (POT) values to a Weibull distribution using the maximum likelihood method (as implemented in the WAFO[1] toolbox). The POT members are selected using a 95% threshold with a 24 hour window.

Contours of the return period values where constructed from the joint PDF using the Inverse FORM method (Winterstein *et al.* 1993) at the 1,10,50,100,1,000 and 10,000 year levels.

3.3. Conditional non-exceedance probabilities

Conditional non-exceedance probabilities are defined as:

$$p(x, y1, y2) = P[X < x | y_1 < Y < y_2]$$

for two variables x and y, with p expressed as a percentage.

[1]Available with supporting documentation at http://www.maths.lth.se/matstat/wafo

4. WIND STATISTICS

Summary wind speed statistics for the site are provided in Table 4.1. Note these data approximate the 10-minute mean at 10 m elevation above the sea surface. The annual mean wind speed is 9.15 $m.s^{-1}$, while the windiest month is June (mean 9.82 $m.s^{-1}$) and the least windy month is February (mean 8.60 $m.s^{-1}$); windspeed statistics show relatively little seasonal variation. During June, the wind speed exceeds 14.84 $m.s^{-1}$ for 10 % of the time (i.e. the 90th percentile non-exceedence level – P90) while in February the P90 wind speed level is 13.24 $m.s^{-1}$.

Monthly and annual wind speed exceedences are presented in Table 4.2. The annual and seasonal joint probability distributions of wind speed and wind direction are provided in Tables 4.3 – 4.7. These same data are also presented as wind rose plots in Figures 4.1 – 4.5. Wind directionality is predominantly westerly, with the W and NW octants showing highest occurrence. The higher wind speeds > 16 m/s show greatest occurrence in the SW octant.

Seasonal variability of wind speed and direction is small, indicating a relatively constant wind climate throughout the year.

Table 4.1 Wind speed statistics (1989-2010) for the 10-minute mean at 10 m elevation.

Wind speed ($m.s^{-1}$)	Mean	Median	P90	P95	P99	Max
Jan	8.72	8.60	12.96	14.41	17.12	23.53
Feb	8.60	8.46	13.24	14.55	17.38	26.65
Mar	8.87	8.83	13.38	14.79	17.72	25.55
Apr	9.41	9.35	14.34	15.74	18.80	25.85
May	9.45	9.26	14.28	15.65	18.49	26.71
Jun	9.82	9.70	14.84	16.35	19.50	25.23
Jul	9.75	9.61	14.58	16.07	18.68	25.77
Aug	9.54	9.43	14.44	15.74	18.06	24.56
Sep	9.11	8.86	14.04	15.71	19.35	25.30
Oct	9.00	8.87	13.71	15.04	17.92	26.05
Nov	8.80	8.69	13.17	14.42	17.16	22.90
Dec	8.67	8.51	13.13	14.47	17.24	27.65
All	9.15	9.01	13.89	15.32	18.27	27.65

Table 4.2 Wind speed exceedence (%) for the 10-minute mean at 10 m elevation.

Wind speed ($m.s^{-1}$)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
> 0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
> 2	98.44	97.79	98.11	98.35	98.70	98.76	98.81	98.72	98.42	98.31	98.46	98.29	98.43
> 4	92.58	90.83	91.70	92.62	94.08	94.05	94.72	93.84	92.53	92.01	92.10	91.42	92.72
> 6	78.31	75.63	78.81	80.82	83.21	83.39	84.57	82.56	79.68	78.95	79.32	77.33	80.24
> 8	56.96	54.88	59.23	64.33	64.13	66.46	66.86	65.19	59.42	59.18	58.13	56.19	60.95
> 10	34.60	33.51	36.73	42.91	41.56	46.99	45.59	43.80	37.62	38.61	35.86	33.82	39.33
> 12	16.17	16.77	18.07	23.78	23.40	28.21	26.62	24.84	20.87	19.98	17.36	16.78	21.09
> 14	6.02	6.81	7.33	11.57	11.31	14.09	12.66	12.26	10.14	8.64	6.44	6.41	9.48
> 16	2.02	2.15	2.65	4.31	4.01	5.90	5.16	4.32	4.42	2.92	1.82	2.15	3.49
> 18	0.60	0.72	0.89	1.52	1.30	2.22	1.59	1.05	1.85	0.95	0.59	0.65	1.16
> 20	0.18	0.28	0.27	0.47	0.49	0.78	0.37	0.43	0.64	0.20	0.13	0.21	0.37
> 22	0.07	0.12	0.07	0.12	0.14	0.20	0.09	0.11	0.10	0.10	0.01	0.07	0.10
> 24	0.00	0.05	0.02	0.01	0.04	0.02	0.01	0.02	0.01	0.02	0.00	0.03	0.02
> 26	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00

Table 4.3 Annual joint probability distribution (parts-per-thousand) of the wind speed and wind direction at 10 m elevation.

Wind speed ($m.s^{-1}$)	Wind direction (degT)								
	337.5 to 22.5	22.5 to 67.5	67.5 to 112.5	112.5 to 157.5	157.5 to 202.5	202.5 to 247.5	247.5 to 292.5	292.5 to 337.5	Total
> 0 <= 2	1.9	1.4	1.4	1.6	1.9	2.5	2.6	2.3	15.6
> 2 <= 4	6.6	4.2	3.6	3.8	5.8	9.8	12.3	11.1	57.2
> 4 <= 6	15.0	6.8	4.1	4.4	9.6	22.7	32.8	29.5	124.9
> 6 <= 8	24.1	7.5	3.7	4.5	11.9	34.2	56.5	50.7	193.1
> 8 <= 10	29.6	6.1	2.9	3.7	11.8	39.2	62.0	60.8	216.1
> 10 <= 12	28.8	3.9	2.0	2.7	8.9	36.1	48.8	51.2	182.4
> 12 <= 14	19.5	2.3	1.2	1.5	6.3	27.3	30.1	27.9	116.1
> 14 <= 16	10.1	1.3	0.9	0.7	3.7	17.3	15.7	10.3	60.0
> 16 <= 18	3.9	0.5	0.2	0.3	1.9	8.0	5.8	2.8	23.4
> 18 <= 20	0.7	0.1	0.1	0.1	0.7	3.4	2.2	0.6	7.9
> 20 <= 22	0.2	0.0	0.0	0.1	0.3	1.3	0.6	0.1	2.6
> 22 <= 24	0.0	0.0	0.0	0.0	0.1	0.4	0.2	0.0	0.7
> 24 <= 26	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
> 26 <= 28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	140.4	34.1	20.1	23.4	62.9	202.2	269.7	247.3	1000

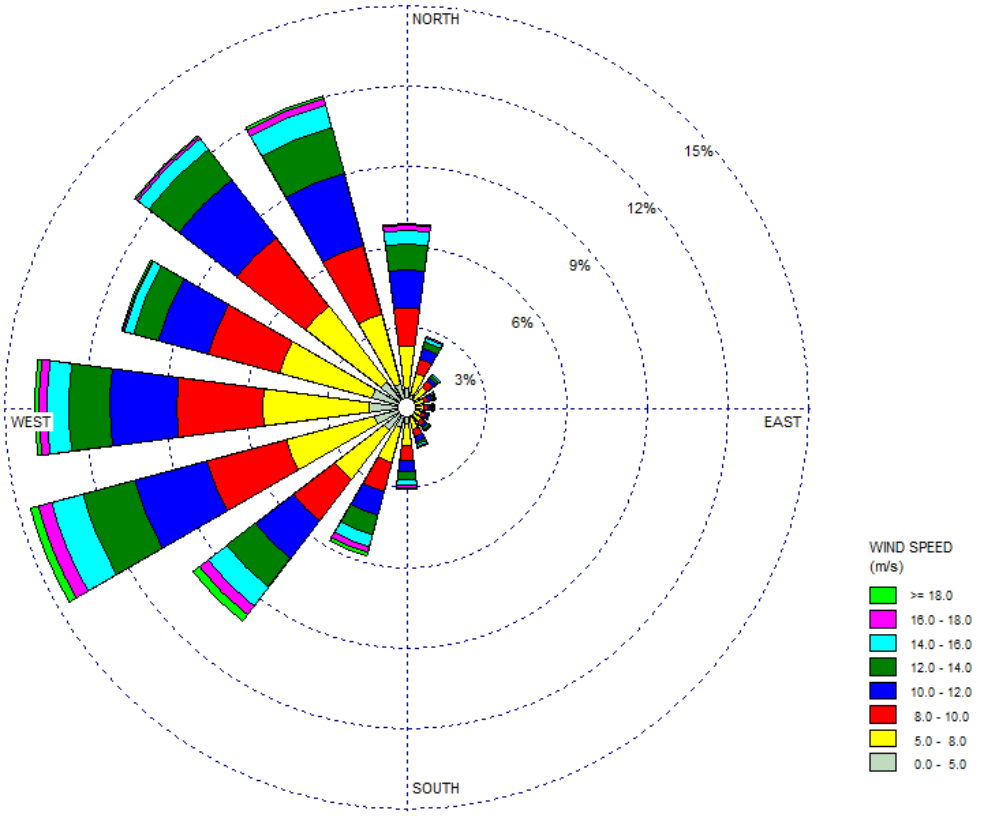

Figure 4.1 Annual wind rose.

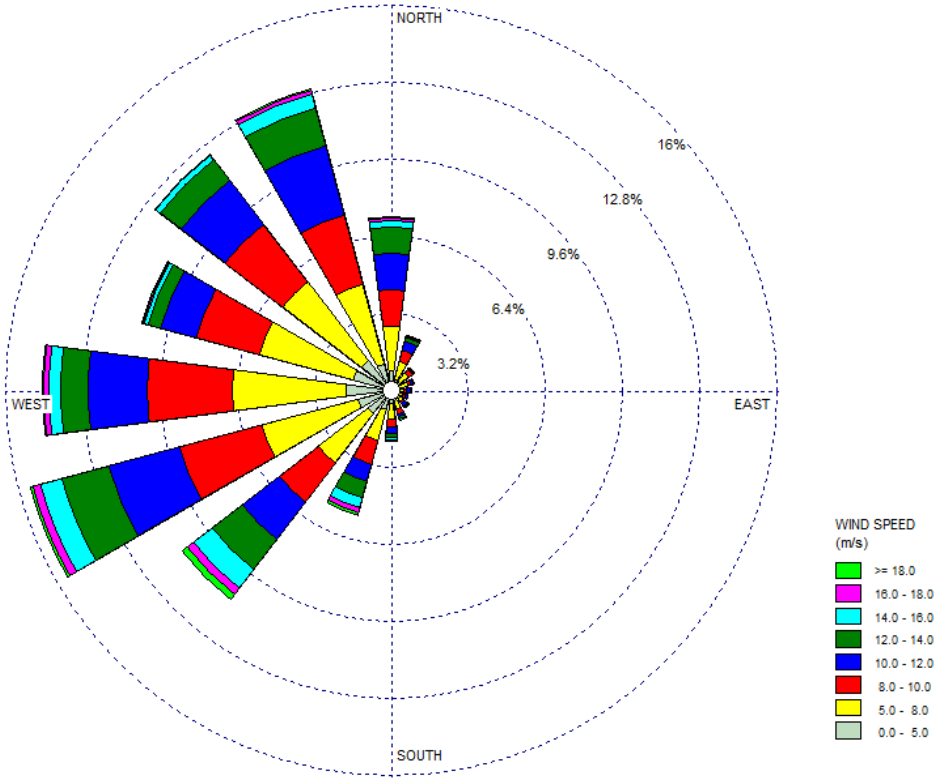

Figure 4.2 Summer (Dec-Feb) wind rose.

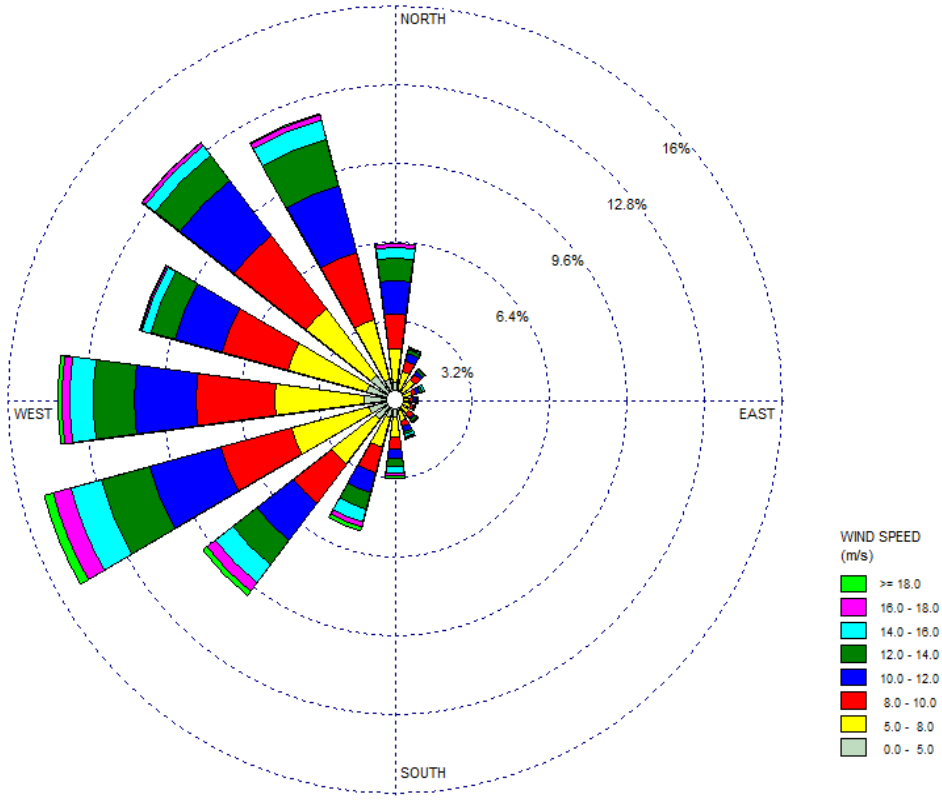

Figure 4.3 Autumn (Mar-May) wind rose.

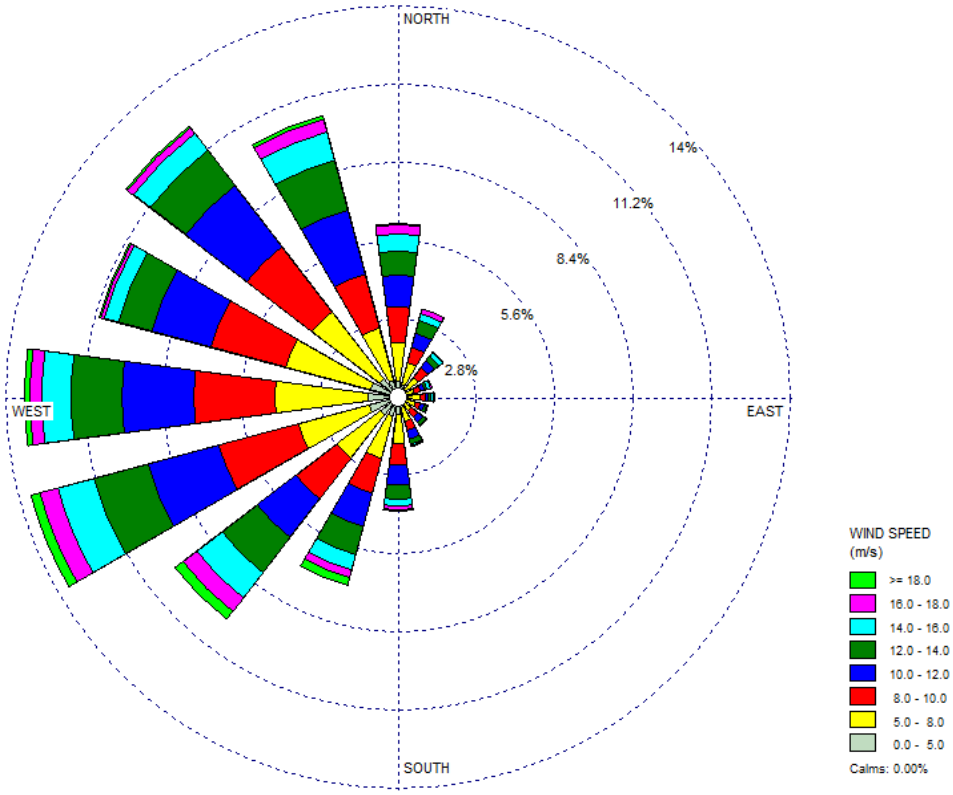

Figure 4.4 Winter (Jun-Aug) wind rose.

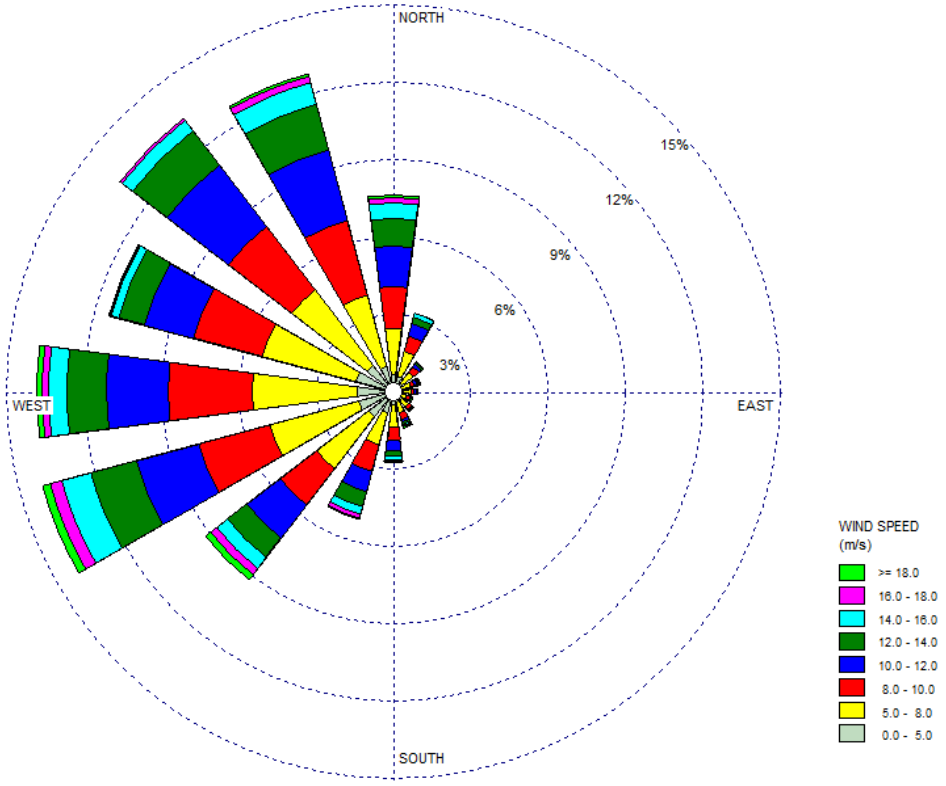

Figure 4.5 Spring (Sep-Nov) wind rose.

5. WAVE CLIMATE

5.1. Statistics

The annual and monthly total significant wave height statistics are provided for the site in Table 5.1, with the sea and swell partitions in Tables 5.2 and 5.3 respectively. Total significant wave height exceedance values are presented in Table 5.4.

The joint probability distributions of wave height and peak wave period are presented in Tables 5.5-5.9, 5.10-5.14, and 5.15-5.19 for total, sea and swell partitions respectively. Joint probability of total significant wave height and wave direction is provided in Tables 5.20-5.24. Annual and seasonal wave roses are shown in Figures 5.1-5.5.

The wave climate is typically moderate to high energy, with a mean annual significant wave height of 2.02 m. The 99^{h} percentile height (P99) is 5.03 m, meaning that this threshold is exceeded 1 % of the time on average. The most energetic month is June, with a mean significant height of 2.33 and P99 is 5.60 m. January has the lowest ambient wave heights, with a mean of 1.74 m, while February shows the lowest values for P99 and maxima. The largest single significant wave height in the 22 year time series is 8.96 m.

The inter-annual variability of the wave climate is relatively small with an approximately 10% variation of mean wave height. The variability increases with higher percentile heights, becoming around 30% at the P99 level.

The significant wave height and peak period joint probability distribution (Table 5.5) indicates that the sea state is predominantly 4-10 seconds with 6-8 seconds occurring almost 50 % of the time. Larger wave events are typically associated with 8 – 12 s peak periods, indicating a local source for wave generation. The period distribution of the sea partition is similar to that of the total, while the swell partition shows a distribution extending to longer periods. Note that the definition of sea/swell utilised does not imply any particular period.

The wave climate is dominated by the westerly sector with the SW the dominant octant on an annual basis; the SW octant is also the most energetic. There is relatively little seasonal variation in directional distribution, however the NW sector becomes slightly dominant in terms of frequency during spring. The wave roses provide a finer directional breakdown and shown that the SW sector has a strongly preferred WSW mode.

5.2. Bivariate RPV of total significant wave height and peak wave period

The contours of bivariate RPV of significant wave height and peak period are shown in Figures 5.6 for the annual conditions. The annual RPV values for total significant wave height are presented in Table 5.28, sectored by directional octant, and as omni-directional values.

Omni-directional estimates of RPV are 6.72, 8.62 and 10.24 m at the 1,10 and 100 year levels. The distribution of peak spectral period is fairly narrow in the bivariate estimates, consistent with the peak wave height conditions being predominantly fully developed seas.

The directional distribution for RPV estimates show largest values from the westerly sector. The W octant has the largest values at the 100 year level, which does not exactly follow the ambient preferred SW direction.

Table 5.1 Total significant wave height statistics.

H_s (m)	Statistic					
	Mean	**Median**	**P90**	**P95**	**P99**	**Max**
January	1.74	1.59	2.71	3.15	4.58	7.01
February	1.81	1.65	2.95	3.46	4.44	6.80
March	1.94	1.79	3.07	3.56	4.93	8.23
April	2.12	1.95	3.45	4.05	5.18	6.95
May	2.15	2.00	3.43	3.93	4.96	8.96
June	2.33	2.17	3.77	4.33	5.60	8.23
July	2.30	2.17	3.54	4.07	5.50	8.67
August	2.21	2.06	3.41	3.92	5.06	7.87
September	2.07	1.84	3.40	3.99	5.31	8.77
October	1.95	1.79	3.05	3.50	4.97	8.27
November	1.84	1.70	2.89	3.33	4.28	5.79
December	1.78	1.62	2.79	3.26	4.39	8.03
1989	1.83	1.70	2.93	3.30	4.52	6.04
1990	2.10	1.89	3.52	4.15	5.14	6.54
1991	1.89	1.73	3.14	3.54	4.32	5.77
1992	1.90	1.74	3.07	3.56	4.84	6.99
1993	1.90	1.76	2.94	3.35	4.37	7.14
1994	1.94	1.76	3.11	3.55	4.72	6.66
1995	2.08	1.91	3.27	3.84	5.08	8.77
1996	2.11	1.93	3.39	4.02	5.26	6.51
1997	2.01	1.88	3.23	3.81	5.05	6.63
1998	1.92	1.73	3.19	3.76	5.41	6.75
1999	1.95	1.80	3.12	3.58	4.64	6.66
2000	2.05	1.92	3.30	3.87	4.89	5.96
2001	2.00	1.85	3.12	3.55	4.65	6.45
2002	2.06	1.91	3.25	3.73	4.92	6.41
2003	2.07	1.81	3.58	4.07	5.43	8.23
2004	2.02	1.86	3.11	3.65	5.55	8.67
2005	1.97	1.80	3.20	3.66	4.80	6.54
2006	2.13	1.95	3.44	4.01	5.00	6.23
2007	2.03	1.91	3.16	3.57	4.40	5.48
2008	2.11	1.93	3.36	3.87	5.16	7.00
2009	2.22	2.01	3.55	4.34	5.80	8.96
2010	2.21	2.01	3.53	4.19	5.86	8.03
All	2.02	1.85	3.25	3.78	5.03	8.96

Table 5.2 Significant sea wave height statistics.

H_s (m)	Statistic					
	Mean	**Median**	**P90**	**P95**	**P99**	**Max**
January	1.71	1.55	2.85	3.45	4.82	7.01
February	1.80	1.65	3.13	3.61	4.72	6.79
March	1.90	1.75	3.20	3.72	5.07	8.22
April	2.10	1.90	3.57	4.19	5.34	6.95
May	2.10	1.96	3.53	4.01	5.15	8.96
June	2.32	2.17	3.92	4.53	5.74	8.22
July	2.22	2.05	3.61	4.21	5.60	7.95
August	2.16	2.03	3.53	4.02	5.18	7.87
September	2.01	1.77	3.52	4.11	5.55	8.77
October	1.87	1.69	3.08	3.61	5.08	8.27
November	1.78	1.64	2.98	3.46	4.43	5.79
December	1.75	1.60	2.94	3.41	4.61	8.03
1989	1.79	1.64	3.02	3.48	5.03	6.04
1990	2.11	1.90	3.72	4.37	5.25	6.54
1991	1.93	1.81	3.28	3.69	4.39	5.77
1992	1.88	1.69	3.20	3.72	5.06	6.99
1993	1.83	1.69	3.06	3.43	4.55	7.14
1994	1.94	1.79	3.28	3.71	5.13	6.66
1995	2.05	1.89	3.38	4.11	5.25	8.77
1996	2.06	1.84	3.62	4.25	5.49	6.51
1997	2.00	1.85	3.35	4.01	5.27	6.62
1998	1.91	1.71	3.39	3.94	5.60	6.75
1999	1.93	1.78	3.29	3.72	4.84	6.65
2000	1.99	1.85	3.38	3.98	4.86	5.94
2001	1.95	1.79	3.21	3.75	4.99	6.44
2002	1.97	1.82	3.34	3.77	4.81	6.41
2003	2.03	1.78	3.71	4.22	5.64	8.22
2004	1.94	1.76	3.23	3.82	5.69	7.95
2005	1.93	1.78	3.26	3.76	4.96	6.54
2006	2.05	1.85	3.51	4.09	5.14	6.23
2007	1.99	1.88	3.24	3.65	4.48	5.48
2008	2.02	1.83	3.45	3.97	5.34	7.00
2009	2.16	1.93	3.69	4.57	5.87	8.96
2010	2.16	1.89	3.69	4.36	6.04	8.03
All	1.98	1.80	3.36	3.93	5.21	8.96

Table 5.3 Significant swell wave height statistics.

H_s (m)	Statistic					
	Mean	**Median**	**P90**	**P95**	**P99**	**Max**
January	0.68	0.56	1.35	1.64	2.15	3.08
February	0.75	0.60	1.52	1.92	2.63	3.81
March	0.77	0.64	1.57	1.86	2.46	4.26
April	0.77	0.62	1.58	1.95	2.75	4.80
May	0.81	0.68	1.63	1.97	2.68	4.75
June	0.84	0.71	1.64	2.00	2.91	4.80
July	0.90	0.75	1.80	2.24	3.28	8.67
August	0.82	0.67	1.67	2.05	2.85	6.00
September	0.84	0.68	1.69	2.18	3.17	5.22
October	0.81	0.66	1.59	2.02	2.85	4.99
November	0.73	0.62	1.49	1.85	2.46	3.54
December	0.68	0.56	1.37	1.68	2.19	4.36
1989	0.72	0.61	1.41	1.76	2.57	3.35
1990	0.73	0.59	1.50	1.76	2.40	4.07
1991	0.69	0.57	1.38	1.69	2.33	3.51
1992	0.77	0.62	1.56	1.94	2.85	4.26
1993	0.72	0.61	1.46	1.78	2.36	4.02
1994	0.77	0.65	1.48	1.80	2.49	3.38
1995	0.76	0.62	1.59	2.02	2.77	3.53
1996	0.81	0.68	1.74	2.04	2.69	4.80
1997	0.81	0.65	1.65	2.09	3.17	4.07
1998	0.69	0.59	1.38	1.67	2.25	3.11
1999	0.74	0.64	1.41	1.72	2.43	4.18
2000	0.80	0.62	1.65	2.09	3.33	5.22
2001	0.78	0.64	1.61	1.94	2.65	4.01
2002	0.84	0.70	1.68	2.01	2.92	6.00
2003	0.81	0.65	1.61	1.98	3.17	4.80
2004	0.81	0.67	1.58	1.92	2.74	8.67
2005	0.79	0.66	1.57	1.91	2.69	4.99
2006	0.83	0.67	1.71	2.06	3.06	4.67
2007	0.72	0.60	1.41	1.70	2.44	3.81
2008	0.88	0.70	1.84	2.36	3.17	5.07
2009	0.83	0.71	1.69	2.02	2.64	4.75
2010	0.87	0.74	1.76	2.07	2.76	4.24
All	0.78	0.64	1.58	1.93	2.74	8.67

Table 5.4 Total significant wave height exceedence values.

H_s (m)	Exceedence (%)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
> 0.5	99.87	98.65	99.71	98.72	99.60	100.00	99.77	99.68	99.51	99.23	99.42	99.39	99.47
> 1	86.74	85.53	90.35	89.80	92.36	94.01	94.72	94.02	91.98	90.92	89.59	86.83	90.60
> 1.5	55.96	57.91	66.98	71.71	72.80	76.89	78.89	77.60	69.91	66.43	61.75	57.36	67.90
> 2	29.09	33.69	38.81	47.82	50.32	57.01	57.70	52.74	43.07	39.88	35.40	32.76	43.24
> 2.5	14.00	18.22	20.36	29.31	30.52	36.83	36.07	33.03	26.41	21.58	18.19	15.88	25.06
> 3	6.23	9.38	10.95	16.93	17.28	22.46	21.22	17.93	15.52	10.88	8.55	7.48	13.74
> 3.5	3.46	4.62	5.47	9.38	9.15	13.59	10.62	8.99	8.95	5.07	3.91	3.41	7.22
> 4	2.10	2.07	2.83	5.30	4.45	7.63	5.53	4.40	4.95	2.74	1.67	1.76	3.79
> 4.5	1.09	0.87	1.67	2.83	1.89	4.29	3.10	2.31	2.56	1.75	0.67	0.87	1.99
> 5	0.61	0.55	0.88	1.48	0.96	2.17	1.63	1.07	1.47	0.91	0.30	0.48	1.04
> 5.5	0.29	0.28	0.53	0.56	0.57	1.13	1.00	0.67	0.81	0.48	0.06	0.27	0.56
> 6	0.18	0.12	0.27	0.17	0.29	0.49	0.45	0.32	0.38	0.22	0.00	0.19	0.26
> 6.5	0.05	0.06	0.15	0.04	0.15	0.16	0.22	0.16	0.20	0.11	0.00	0.15	0.12
> 7	0.01	0.00	0.07	0.00	0.06	0.09	0.12	0.08	0.11	0.05	0.00	0.08	0.06
> 7.5	0.00	0.00	0.05	0.00	0.05	0.04	0.09	0.03	0.08	0.04	0.00	0.05	0.04
> 8	0.00	0.00	0.02	0.00	0.04	0.02	0.03	0.00	0.07	0.01	0.00	0.01	0.02
> 8.5	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.01

Table 5.5 Annual joint probability distribution (parts per thousand) of total significant wave height and peak spectral wave period.

	Peak spectral wave period (s)									
H_s (m)	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18+**	**Total**
> 0 <= 0.5	0.0	2.4	1.2	0.5	0.5	0.4	0.2	0.1	0.0	5.3
> 0.5 <= 1	3.0	38.5	26.3	14.5	4.7	0.9	0.5	0.2	0.0	88.6
> 1 <= 1.5	1.2	95.1	86.1	31.6	11.0	1.4	0.4	0.2	0.0	227.0
> 1.5 <= 2	0.0	77.4	127.1	27.4	13.7	1.5	0.1	0.1	0.1	247.4
> 2 <= 2.5	0.0	17.5	127.2	24.4	10.4	1.4	0.1	0.0	0.0	181.0
> 2.5 <= 3	0.0	0.8	78.9	25.4	6.4	1.5	0.1	0.0	0.0	113.1
> 3 <= 3.5	0.0	0.0	34.4	27.1	2.7	0.9	0.1	0.0	0.0	65.2
> 3.5 <= 4	0.0	0.0	8.9	23.2	1.8	0.5	0.1	0.0	0.0	34.5
> 4 <= 4.5	0.0	0.0	0.9	15.4	1.3	0.1	0.1	0.0	0.0	17.8
> 4.5 <= 5	0.0	0.0	0.1	7.5	1.8	0.1	0.0	0.0	0.0	9.5
> 5 <= 5.5	0.0	0.0	0.0	2.8	2.0	0.1	0.0	0.0	0.0	4.9
> 5.5 <= 6	0.0	0.0	0.0	0.9	2.0	0.1	0.0	0.0	0.0	3.0
> 6 <= 6.5	0.0	0.0	0.0	0.2	1.1	0.0	0.0	0.0	0.0	1.3
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.6
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Total	4.2	231.7	491.1	200.9	60.5	9.0	1.7	0.6	0.1	1000

Table 5.6 Joint probability distribution (parts per thousand) of total significant wave height and peak spectral wave period during winter (Jun-Aug).

	Peak spectral wave period (s)									
H_s (m)	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18+**	**Total**
> 0 <= 0.5	0.0	1.0	0.3	0.2	0.2	0.0	0.0	0.0	0.0	1.7
> 0.5 <= 1	2.1	24.8	17.3	8.1	2.2	0.8	0.3	0.0	0.0	55.6
> 1 <= 1.5	0.8	61.9	62.5	27.5	9.2	2.1	0.3	0.0	0.0	164.3
> 1.5 <= 2	0.0	59.6	110.8	32.0	16.6	1.4	0.2	0.0	0.3	220.9
> 2 <= 2.5	0.0	20.0	135.5	29.9	17.5	1.1	0.0	0.0	0.1	204.1
> 2.5 <= 3	0.0	1.6	100.5	34.1	10.4	1.1	0.0	0.0	0.0	147.7
> 3 <= 3.5	0.0	0.0	50.3	39.1	4.0	1.2	0.1	0.0	0.0	94.7
> 3.5 <= 4	0.0	0.0	14.1	34.6	3.3	0.3	0.0	0.0	0.0	52.3
> 4 <= 4.5	0.0	0.0	1.1	22.7	1.9	0.1	0.0	0.0	0.0	25.8
> 4.5 <= 5	0.0	0.0	0.0	13.0	2.9	0.2	0.0	0.0	0.0	16.1
> 5 <= 5.5	0.0	0.0	0.0	3.8	2.8	0.1	0.0	0.0	0.0	6.7
> 5.5 <= 6	0.0	0.0	0.0	1.5	3.4	0.3	0.0	0.0	0.0	5.2
> 6 <= 6.5	0.0	0.0	0.0	0.4	1.9	0.0	0.0	0.0	0.0	2.3
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.8
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.4
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.3
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.9	168.9	492.4	246.9	77.7	8.9	0.9	0.0	0.4	1000

Table 5.7 Joint probability distribution (parts per thousand) of total significant wave height and peak spectral wave period during spring (Sep-Nov).

	Peak spectral wave period (s)									
H_s (m)	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18+**	**Total**
> 0 <= 0.5	0.0	2.9	1.3	0.3	0.4	0.9	0.2	0.1	0.0	6.1
> 0.5 <= 1	3.6	30.9	24.8	18.6	6.1	0.8	0.2	0.3	0.1	85.4
> 1 <= 1.5	1.3	97.2	93.7	38.3	15.0	1.6	0.6	0.2	0.0	247.9
> 1.5 <= 2	0.0	93.2	130.1	25.4	15.2	2.3	0.0	0.1	0.0	266.3
> 2 <= 2.5	0.0	18.4	123.3	20.4	9.5	2.0	0.0	0.0	0.0	173.6
> 2.5 <= 3	0.0	0.6	70.8	22.5	7.0	2.9	0.3	0.0	0.0	104.1
> 3 <= 3.5	0.0	0.0	30.5	21.7	3.0	1.4	0.2	0.0	0.0	56.8
> 3.5 <= 4	0.0	0.0	6.8	18.8	1.9	0.9	0.2	0.0	0.0	28.6
> 4 <= 4.5	0.0	0.0	0.7	12.2	1.0	0.2	0.2	0.0	0.0	14.3
> 4.5 <= 5	0.0	0.0	0.1	5.7	1.7	0.1	0.1	0.0	0.0	7.7
> 5 <= 5.5	0.0	0.0	0.0	2.6	1.8	0.0	0.0	0.0	0.0	4.4
> 5.5 <= 6	0.0	0.0	0.0	0.7	1.8	0.0	0.0	0.0	0.0	2.5
> 6 <= 6.5	0.0	0.0	0.0	0.1	0.8	0.0	0.0	0.0	0.0	0.9
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.5
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Total	4.9	243.2	482.1	187.3	66.1	13.1	2.0	0.7	0.1	1000

Table 5.8 Joint probability distribution (parts per thousand) of total significant wave height and peak spectral wave period during summer (Dec-Feb).

	Peak spectral wave period (s)									
H_s (m)	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18+**	**Total**
> 0 <= 0.5	0.0	3.5	2.1	0.1	0.0	0.1	0.5	0.4	0.0	6.7
> 0.5 <= 1	3.7	62.8	38.2	18.3	4.2	0.5	0.9	0.6	0.1	129.3
> 1 <= 1.5	1.7	135.5	119.3	28.7	7.3	0.3	0.1	0.4	0.1	293.4
> 1.5 <= 2	0.0	89.1	136.9	21.5	5.5	0.5	0.0	0.0	0.0	253.5
> 2 <= 2.5	0.0	15.3	118.2	19.6	4.1	0.2	0.0	0.0	0.0	157.4
> 2.5 <= 3	0.0	0.4	62.4	16.8	3.3	0.5	0.0	0.0	0.0	83.4
> 3 <= 3.5	0.0	0.0	20.6	15.8	1.6	0.3	0.0	0.0	0.0	38.3
> 3.5 <= 4	0.0	0.0	4.2	13.9	0.3	0.0	0.0	0.0	0.0	18.4
> 4 <= 4.5	0.0	0.0	0.5	9.4	0.3	0.0	0.0	0.0	0.0	10.2
> 4.5 <= 5	0.0	0.0	0.0	3.1	0.8	0.0	0.0	0.0	0.0	3.9
> 5 <= 5.5	0.0	0.0	0.0	1.6	1.0	0.0	0.0	0.0	0.0	2.6
> 5.5 <= 6	0.0	0.0	0.0	0.5	0.7	0.0	0.0	0.0	0.0	1.2
> 6 <= 6.5	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.0	0.8
> 6.5 <= 7	0.0	0.0	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.6
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	5.4	306.6	502.4	149.5	30.5	2.5	1.5	1.4	0.2	1000

Table 5.9 Joint probability distribution (parts per thousand) of total significant wave height and peak spectral wave period during autumn (Mar-May).

	Peak spectral wave period (s)									
H_s **(m)**	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18+**	**Total**
> 0 <= 0.5	0.1	2.3	0.9	1.5	1.2	0.5	0.0	0.0	0.0	6.5
> 0.5 <= 1	2.6	36.0	25.0	13.1	6.4	1.4	0.5	0.1	0.0	85.1
> 1 <= 1.5	0.9	86.8	69.4	31.9	12.4	1.4	0.6	0.3	0.0	203.7
> 1.5 <= 2	0.0	68.1	130.8	30.6	17.5	1.8	0.4	0.1	0.0	249.3
> 2 <= 2.5	0.0	16.4	131.5	27.4	10.5	2.2	0.4	0.0	0.0	188.4
> 2.5 <= 3	0.0	0.7	81.3	28.1	4.7	1.6	0.2	0.0	0.0	116.6
> 3 <= 3.5	0.0	0.0	35.9	31.7	2.3	0.6	0.0	0.0	0.0	70.5
> 3.5 <= 4	0.0	0.0	10.3	25.4	1.7	0.7	0.1	0.0	0.0	38.2
> 4 <= 4.5	0.0	0.0	1.5	16.9	1.9	0.1	0.0	0.0	0.0	20.4
> 4.5 <= 5	0.0	0.0	0.1	8.0	1.9	0.1	0.0	0.0	0.0	10.1
> 5 <= 5.5	0.0	0.0	0.0	3.1	2.3	0.1	0.0	0.0	0.0	5.5
> 5.5 <= 6	0.0	0.0	0.0	1.0	2.2	0.0	0.0	0.0	0.0	3.2
> 6 <= 6.5	0.0	0.0	0.0	0.3	0.9	0.0	0.0	0.0	0.0	1.2
> 6.5 <= 7	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.0	0.0	0.7
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Total	3.6	210.3	486.7	219.1	66.8	10.6	2.2	0.5	0.0	1000

Table 5.10 Annual joint probability distribution (parts per thousand) of significant sea wave height and peak spectral sea wave period.

H_s (m)	Peak spectral sea wave period (s)						
	2-4	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**Total**
> 0 <= 0.5	15.2	13.6	1.6	0.1	0.0	0.0	30.5
> 0.5 <= 1	31.5	84.9	10.5	0.4	0.0	0.0	127.3
> 1 <= 1.5	1.3	160.3	43.2	1.5	0.1	0.0	206.4
> 1.5 <= 2	0.0	106.1	103.1	2.4	0.1	0.0	211.7
> 2 <= 2.5	0.0	16.7	134.2	9.4	0.3	0.0	160.6
> 2.5 <= 3	0.0	0.4	90.2	18.3	0.5	0.1	109.5
> 3 <= 3.5	0.0	0.0	40.0	28.4	0.3	0.0	68.7
> 3.5 <= 4	0.0	0.0	10.0	28.8	0.6	0.0	39.4
> 4 <= 4.5	0.0	0.0	1.0	18.9	0.9	0.0	20.8
> 4.5 <= 5	0.0	0.0	0.1	9.7	2.1	0.0	11.9
> 5 <= 5.5	0.0	0.0	0.0	3.6	2.4	0.0	6.0
> 5.5 <= 6	0.0	0.0	0.0	1.2	2.6	0.0	3.8
> 6 <= 6.5	0.0	0.0	0.0	0.3	1.4	0.0	1.7
> 6.5 <= 7	0.0	0.0	0.0	0.1	0.8	0.0	0.9
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.2	0.0	0.2
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.2	0.1	0.3
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.1	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Total	48.0	382.0	433.9	123.1	12.7	0.2	1000

Table 5.11 Joint probability distribution (parts per thousand) of significant sea wave height and peak spectral sea wave period during winter (Jun-Aug).

H_s (m)	Peak spectral sea wave period (s)						
	2-4	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**Total**
> 0 <= 0.5	10.5	7.4	1.0	0.1	0.0	0.0	19.0
> 0.5 <= 1	24.1	60.7	7.9	0.5	0.0	0.0	93.2
> 1 <= 1.5	1.3	120.4	38.3	1.5	0.1	0.0	161.6
> 1.5 <= 2	0.0	94.9	100.1	2.4	0.2	0.0	197.6
> 2 <= 2.5	0.0	18.2	145.4	11.7	0.6	0.0	175.9
> 2.5 <= 3	0.0	0.7	110.3	22.3	0.8	0.0	134.1
> 3 <= 3.5	0.0	0.0	56.3	37.2	0.4	0.0	93.9
> 3.5 <= 4	0.0	0.0	14.6	41.2	0.8	0.0	56.6
> 4 <= 4.5	0.0	0.0	1.1	26.7	1.5	0.0	29.3
> 4.5 <= 5	0.0	0.0	0.0	16.1	3.3	0.1	19.5
> 5 <= 5.5	0.0	0.0	0.0	4.7	3.5	0.1	8.3
> 5.5 <= 6	0.0	0.0	0.0	1.9	4.2	0.0	6.1
> 6 <= 6.5	0.0	0.0	0.0	0.5	2.4	0.0	2.9
> 6.5 <= 7	0.0	0.0	0.0	0.0	1.0	0.0	1.0
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.4	0.1	0.5
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.3	0.1	0.4
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.1	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	35.9	302.3	475.0	166.8	19.6	0.4	1000

Table 5.12 Joint probability distribution (parts per thousand) of significant sea wave height and peak spectral sea wave period during spring (Sep-Nov).

H_s (m)	Peak spectral sea wave period (s)						
	2-4	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**Total**
> 0 <= 0.5	17.4	15.4	2.0	0.1	0.0	0.0	34.9
> 0.5 <= 1	35.0	87.6	10.8	0.4	0.0	0.0	133.8
> 1 <= 1.5	1.4	182.8	46.7	1.6	0.0	0.0	232.5
> 1.5 <= 2	0.0	119.8	99.7	1.6	0.2	0.0	221.3
> 2 <= 2.5	0.0	17.1	128.5	7.0	0.3	0.0	152.9
> 2.5 <= 3	0.0	0.3	82.9	15.1	0.4	0.0	98.7
> 3 <= 3.5	0.0	0.0	34.8	21.7	0.1	0.0	56.6
> 3.5 <= 4	0.0	0.0	8.0	23.6	0.4	0.0	32.0
> 4 <= 4.5	0.0	0.0	0.8	15.1	0.7	0.0	16.6
> 4.5 <= 5	0.0	0.0	0.1	7.6	2.1	0.0	9.8
> 5 <= 5.5	0.0	0.0	0.0	3.2	1.7	0.0	4.9
> 5.5 <= 6	0.0	0.0	0.0	1.0	2.3	0.0	3.3
> 6 <= 6.5	0.0	0.0	0.0	0.2	1.1	0.0	1.3
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.6	0.0	0.6
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.2	0.0	0.2
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.2	0.0	0.2
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.2	0.0	0.2
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.2	0.0	0.2
Total	53.8	423.0	414.3	98.2	10.7	0.0	1000

Table 5.13 Joint probability distribution (parts per thousand) of significant sea wave height and peak spectral sea wave period during summer (Dec-Feb).

H_s (m)	Peak spectral sea wave period (s)						
	2-4	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**Total**
> 0 <= 0.5	18.9	19.9	2.4	0.1	0.0	0.0	41.3
> 0.5 <= 1	35.9	115.7	15.1	0.5	0.0	0.0	167.2
> 1 <= 1.5	1.5	190.1	49.6	1.6	0.1	0.0	242.9
> 1.5 <= 2	0.0	113.8	100.1	1.7	0.0	0.0	215.6
> 2 <= 2.5	0.0	15.7	125.4	7.4	0.1	0.0	148.6
> 2.5 <= 3	0.0	0.3	74.1	13.6	0.9	0.2	89.1
> 3 <= 3.5	0.0	0.0	26.1	19.1	0.8	0.0	46.0
> 3.5 <= 4	0.0	0.0	5.4	17.8	0.0	0.0	23.2
> 4 <= 4.5	0.0	0.0	0.5	12.4	0.3	0.0	13.2
> 4.5 <= 5	0.0	0.0	0.1	4.3	1.1	0.0	5.5
> 5 <= 5.5	0.0	0.0	0.0	2.3	1.3	0.0	3.6
> 5.5 <= 6	0.0	0.0	0.0	0.6	1.0	0.0	1.6
> 6 <= 6.5	0.0	0.0	0.0	0.1	0.9	0.0	1.0
> 6.5 <= 7	0.0	0.0	0.0	0.1	0.6	0.1	0.8
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.1	0.0	0.1
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.1	0.1	0.2
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	56.3	455.5	398.8	81.6	7.3	0.4	1000

Table 5.14 Joint probability distribution (parts per thousand) of significant sea wave height and peak spectral sea wave period during autumn (Mar-May).

H_s (m)	Peak spectral sea wave period (s)						
	2-4	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**Total**
> 0 <= 0.5	14.4	12.4	1.1	0.2	0.0	0.0	28.1
> 0.5 <= 1	31.5	78.9	8.7	0.2	0.0	0.0	119.3
> 1 <= 1.5	1.1	152.2	38.8	1.4	0.1	0.0	193.6
> 1.5 <= 2	0.0	97.1	112.4	3.7	0.1	0.0	213.3
> 2 <= 2.5	0.0	15.9	136.5	11.0	0.1	0.0	163.5
> 2.5 <= 3	0.0	0.3	91.4	21.5	0.1	0.0	113.3
> 3 <= 3.5	0.0	0.0	41.1	34.5	0.1	0.0	75.7
> 3.5 <= 4	0.0	0.0	11.6	31.4	1.1	0.0	44.1
> 4 <= 4.5	0.0	0.0	1.5	20.4	1.2	0.0	23.1
> 4.5 <= 5	0.0	0.0	0.1	10.1	2.0	0.0	12.2
> 5 <= 5.5	0.0	0.0	0.0	4.0	2.7	0.0	6.7
> 5.5 <= 6	0.0	0.0	0.0	1.3	2.7	0.0	4.0
> 6 <= 6.5	0.0	0.0	0.0	0.4	1.2	0.0	1.6
> 6.5 <= 7	0.0	0.0	0.0	0.1	0.8	0.0	0.9
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.1	0.1	0.2
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.1	0.1	0.2
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.1	0.1	0.2
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Total	47.0	356.8	443.2	140.2	12.6	0.3	1000

Table 5.15 Annual joint probability distribution (parts per thousand) of significant swell wave height and peak spectral swell wave period.

	Peak spectral swell wave period (s)											
H_s (m)	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18-20**	**20-22**	**22-24**	**Total**
> 0 <= 0.5	0.2	26.6	86.3	133.3	85.1	35.9	14.4	7.1	1.7	1.1	0.4	392.1
> 0.5 <= 1	0.0	45.4	123.9	100.9	40.9	7.5	2.2	0.8	0.0	0.0	0.0	321.6
> 1 <= 1.5	0.0	13.1	81.8	50.2	22.4	2.6	0.5	0.0	0.0	0.0	0.0	170.6
> 1.5 <= 2	0.0	0.7	33.4	22.3	14.1	1.8	0.2	0.0	0.0	0.0	0.0	72.5
> 2 <= 2.5	0.0	0.0	8.5	10.7	6.4	1.3	0.2	0.0	0.0	0.0	0.0	27.1
> 2.5 <= 3	0.0	0.0	1.5	4.8	3.1	1.0	0.1	0.0	0.0	0.0	0.0	10.5
> 3 <= 3.5	0.0	0.0	0.1	1.8	1.4	0.6	0.1	0.0	0.0	0.0	0.0	4.0
> 3.5 <= 4	0.0	0.0	0.0	0.3	0.6	0.2	0.1	0.0	0.0	0.0	0.0	1.2
> 4 <= 4.5	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.5
> 4.5 <= 5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
> 5 <= 5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 5.5 <= 6	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	85.8	335.5	324.4	174.4	51.1	17.8	7.9	1.7	1.1	0.4	1000

Table 5.16 Joint probability distribution (parts per thousand) of significant swell wave height and peak spectral swell wave period during winter (Jun-Aug).

	Peak spectral swell wave period (s)											
H_s (m)	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18-20**	**20-22**	**22-24**	**Total**
> 0 <= 0.5	0.1	15.7	70.1	112.1	92.5	41.0	14.7	8.2	1.6	2.2	0.8	359.0
> 0.5 <= 1	0.0	25.5	99.6	106.5	54.1	12.3	4.2	1.1	0.0	0.0	0.0	303.3
> 1 <= 1.5	0.0	8.5	78.3	67.5	33.6	3.7	1.0	0.1	0.0	0.0	0.0	192.7
> 1.5 <= 2	0.0	0.5	33.3	29.8	21.2	1.5	0.2	0.0	0.0	0.0	0.0	86.5
> 2 <= 2.5	0.0	0.0	9.0	13.6	9.4	1.2	0.0	0.0	0.0	0.0	0.0	33.2
> 2.5 <= 3	0.0	0.0	1.7	7.1	4.9	1.3	0.0	0.0	0.0	0.0	0.0	15.0
> 3 <= 3.5	0.0	0.0	0.2	2.9	3.0	0.4	0.0	0.0	0.0	0.0	0.0	6.5
> 3.5 <= 4	0.0	0.0	0.0	0.3	1.4	0.3	0.0	0.0	0.0	0.0	0.0	2.0
> 4 <= 4.5	0.0	0.0	0.0	0.2	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.9
> 4.5 <= 5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
> 5 <= 5.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
> 5.5 <= 6	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.1	50.2	292.2	340.0	220.6	62.4	20.1	9.4	1.6	2.2	0.8	1000

Table 5.17 Joint probability distribution (parts per thousand) of significant swell wave height and peak spectral swell wave period during spring (Sep-Nov).

	Peak spectral swell wave period (s)											
***H_s* (m)**	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18-20**	**20-22**	**22-24**	**Total**
> 0 <= 0.5	0.2	24.0	79.3	130.9	84.5	33.1	15.6	10.2	2.4	1.4	0.7	382.3
> 0.5 <= 1	0.0	40.3	133.7	108.9	40.8	5.7	2.0	0.7	0.0	0.0	0.0	332.1
> 1 <= 1.5	0.0	13.9	83.7	45.0	23.0	3.1	0.1	0.0	0.0	0.0	0.0	168.8
> 1.5 <= 2	0.0	0.6	31.5	19.8	13.0	2.7	0.3	0.0	0.0	0.0	0.0	67.9
> 2 <= 2.5	0.0	0.0	8.3	9.8	7.1	2.2	0.6	0.0	0.0	0.0	0.0	28.0
> 2.5 <= 3	0.0	0.0	1.7	4.8	4.2	1.9	0.3	0.0	0.0	0.0	0.0	12.9
> 3 <= 3.5	0.0	0.0	0.0	1.9	1.5	1.6	0.3	0.0	0.0	0.0	0.0	5.3
> 3.5 <= 4	0.0	0.0	0.0	0.5	0.8	0.3	0.1	0.0	0.0	0.0	0.0	1.7
> 4 <= 4.5	0.0	0.0	0.0	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.6
> 4.5 <= 5	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.5
> 5 <= 5.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
> 5.5 <= 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	78.8	338.2	321.8	175.7	50.8	19.3	10.9	2.4	1.4	0.7	1000

Table 5.18 Joint probability distribution (parts per thousand) of significant swell wave height and peak spectral swell wave period during summer (Dec-Feb) .

	Peak spectral swell wave period (s)											
***H_s* (m)**	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18-20**	**20-22**	**22-24**	**Total**
> 0 <= 0.5	0.3	40.4	121.8	168.2	60.8	24.7	10.6	4.9	1.6	0.5	0.2	434.0
> 0.5 <= 1	0.0	70.7	154.4	83.8	17.9	1.2	0.7	0.1	0.0	0.0	0.0	328.8
> 1 <= 1.5	0.0	20.3	87.4	35.8	9.5	0.5	0.0	0.0	0.0	0.0	0.0	153.5
> 1.5 <= 2	0.0	0.8	34.5	15.6	5.9	0.3	0.0	0.0	0.0	0.0	0.0	57.1
> 2 <= 2.5	0.0	0.0	7.8	7.9	3.8	0.3	0.0	0.0	0.0	0.0	0.0	19.8
> 2.5 <= 3	0.0	0.0	1.4	3.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	5.2
> 3 <= 3.5	0.0	0.0	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.1
> 3.5 <= 4	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
> 4 <= 4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 4.5 <= 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 5 <= 5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 5.5 <= 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.3	132.2	407.3	315.3	99.0	27.0	11.3	5.0	1.6	0.5	0.2	1000

Table 5.19 Joint probability distribution (parts per thousand) of significant swell wave height and peak spectral swell wave period during autumn (Mar-May).

	Peak spectral swell wave period (s)											
***H_s* (m)**	**2-4**	**4 -6**	**6-8**	**8- 10**	**10 - 12**	**12 - 14**	**14 - 16**	**16-18**	**18-20**	**20-22**	**22-24**	**Total**
> 0 <= 0.5	0.2	25.7	73.2	120.8	102.6	45.0	16.5	5.3	1.1	0.2	0.1	390.7
> 0.5 <= 1	0.0	43.9	107.0	104.8	51.1	11.0	2.1	1.1	0.1	0.0	0.0	321.1
> 1 <= 1.5	0.0	9.4	77.5	53.1	23.9	3.2	0.9	0.0	0.0	0.0	0.0	168.0
> 1.5 <= 2	0.0	0.9	34.2	24.3	16.4	2.6	0.1	0.0	0.0	0.0	0.0	78.5
> 2 <= 2.5	0.0	0.0	8.9	11.7	5.5	1.6	0.2	0.0	0.0	0.0	0.0	27.9
> 2.5 <= 3	0.0	0.0	1.1	4.4	2.7	0.9	0.1	0.0	0.0	0.0	0.0	9.2
> 3 <= 3.5	0.0	0.0	0.1	1.7	0.9	0.3	0.0	0.0	0.0	0.0	0.0	3.0
> 3.5 <= 4	0.0	0.0	0.0	0.4	0.3	0.3	0.2	0.0	0.0	0.0	0.0	1.2
> 4 <= 4.5	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
> 4.5 <= 5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
> 5 <= 5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 5.5 <= 6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	79.9	302.0	321.2	203.8	64.9	20.1	6.4	1.2	0.2	0.1	1000

Table 5.20 Annual joint probability distribution (parts per thousand) of total significant wave height and mean wave direction at peak energy.

Hs (m)	Wave direction (degT)								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.5	0.8	1.3	0.4	0.9	0.3	0.8	0.3	0.5	5.3
> 0.5 <= 1	13.6	14.8	7.6	10.5	2.7	13.4	10.8	15.3	88.7
> 1 <= 1.5	36.8	25.6	14.4	22.5	6.3	35.3	35.3	51	227.2
> 1.5 <= 2	37.1	20.2	12.3	18.3	5.7	43.6	47.2	63.1	247.5
> 2 <= 2.5	25.2	10.7	7.1	10.5	5	40.9	38.4	43.1	180.9
> 2.5 <= 3	14.2	5.1	4.3	5.7	2.8	31.5	25.2	24.2	113
> 3 <= 3.5	6.5	1.8	2.1	2.5	2.1	22.2	16	12	65.2
> 3.5 <= 4	2.5	0.9	0.9	1.4	1.2	14.3	8.3	5.1	34.6
> 4 <= 4.5	1.1	0.3	0.3	0.4	0.7	8.5	4.5	2	17.8
> 4.5 <= 5	0.4	0.2	0.3	0.2	0.3	5.1	2.4	0.7	9.6
> 5 <= 5.5	0.1	0.1	0.1	0.1	0.2	2.8	1.1	0.3	4.8
> 5.5 <= 6	0	0	0.1	0.1	0.1	1.7	0.8	0.1	2.9
> 6 <= 6.5	0	0	0	0	0.1	0.9	0.4	0	1.4
> 6.5 <= 7	0	0	0	0	0	0.4	0.2	0	0.6
> 7 <= 7.5	0	0	0	0	0	0.1	0.1	0	0.2
> 7.5 <= 8	0	0	0	0	0	0.2	0	0	0.2
> 8 <= 8.5	0	0	0	0	0	0.1	0	0	0.1
> 8.5 <= 9	0	0	0	0	0	0	0	0	0
Total	138.3	81	49.9	73.1	27.5	221.8	191	217.4	1000

Table 5.21 Joint probability distribution (parts per thousand) of total significant wave height and mean wave direction at peak energy during winter (Jun-Aug).

Hs (m)	Wave direction (degT)								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.5	0.0	0.0	0.0	0.7	0.5	0.5	0.1	0.1	1.9
> 0.5 <= 1	7.7	7.3	5.1	9.7	3.3	9.9	6.4	6.1	55.5
> 1 <= 1.5	27.9	21.9	13.1	21.1	6.3	25.7	20.5	28.0	164.5
> 1.5 <= 2	31.5	17.7	17.5	24.5	7.3	36.7	36.2	49.6	221.0
> 2 <= 2.5	30.2	12.8	10.6	16.5	8.0	42.0	41.0	43.2	204.3
> 2.5 <= 3	20.5	6.4	7.5	8.6	5.3	34.4	32.7	32.4	147.8
> 3 <= 3.5	11.2	2.7	4.5	3.0	3.7	26.2	23.6	19.8	94.7
> 3.5 <= 4	4.3	1.1	2.1	2.1	1.5	19.8	11.0	10.5	52.4
> 4 <= 4.5	1.7	0.5	0.2	0.7	0.7	10.8	6.6	4.7	25.9
> 4.5 <= 5	0.6	0.5	0.2	0.0	0.3	7.7	4.6	2.2	16.1
> 5 <= 5.5	0.0	0.1	0.1	0.1	0.1	3.9	1.7	0.7	6.7
> 5.5 <= 6	0.0	0.0	0.3	0.1	0.1	3.0	1.5	0.2	5.2
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.2	1.5	0.7	0.0	2.4
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.0	0.8
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.4
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	135.6	71.0	61.2	87.1	37.3	223.4	186.9	197.6	1000

Table 5.22 Joint probability distribution (parts per thousand) of total significant wave height and mean wave direction at peak energy during spring (Sep-Nov).

Hs (m)	Wave direction (degT)								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.5	0.4	2.3	0.4	1.0	0.1	0.8	0.5	0.6	6.1
> 0.5 <= 1	10.7	18.5	9.7	8.8	3.5	12.4	10.5	11.4	85.5
> 1 <= 1.5	41.1	37.2	21.2	16.7	8.6	35.2	35.7	52.3	248.0
> 1.5 <= 2	38.9	28.8	12.7	9.8	5.3	43.8	53.0	74.0	266.3
> 2 <= 2.5	27.2	13.7	7.7	5.2	4.0	35.1	35.2	45.5	173.6
> 2.5 <= 3	16.3	9.8	5.1	3.1	1.7	26.5	19.2	22.4	104.1
> 3 <= 3.5	6.9	2.9	1.6	1.9	1.1	19.1	13.0	10.2	56.7
> 3.5 <= 4	2.7	1.1	0.9	1.1	1.0	11.6	7.5	2.7	28.6
> 4 <= 4.5	1.2	0.2	0.7	0.3	0.6	6.9	3.5	1.0	14.4
> 4.5 <= 5	0.5	0.1	0.8	0.2	0.3	4.1	1.4	0.2	7.6
> 5 <= 5.5	0.3	0.1	0.4	0.1	0.2	2.4	0.6	0.3	4.4
> 5.5 <= 6	0.1	0.0	0.2	0.0	0.0	1.4	0.5	0.2	2.4
> 6 <= 6.5	0.1	0.0	0.0	0.0	0.0	0.7	0.1	0.0	0.9
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Total	146.4	114.7	61.4	48.2	26.4	200.7	180.8	220.8	1000

Table 5.23 Joint probability distribution (parts per thousand) of total significant wave height and mean wave direction at peak energy during summer (Dec-Feb) .

Hs (m)	Wave direction (degT)								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.5	1.8	0.8	1.0	0.4	0.4	1.0	0.5	0.9	6.8
> 0.5 <= 1	23.0	22.5	6.7	12.0	2.2	19.7	14.9	28.3	129.3
> 1 <= 1.5	51.8	28.1	9.6	21.9	5.2	48.5	50.5	77.9	293.5
> 1.5 <= 2	40.6	14.3	11.1	10.0	4.0	52.4	54.6	66.5	253.5
> 2 <= 2.5	22.5	5.8	5.1	5.7	2.4	47.1	34.6	34.2	157.4
> 2.5 <= 3	9.2	1.5	2.4	3.1	1.2	32.0	18.5	15.4	83.3
> 3 <= 3.5	2.5	0.0	1.2	1.8	1.6	17.8	8.6	4.9	38.4
> 3.5 <= 4	0.8	0.0	0.2	0.8	0.9	10.5	3.7	1.5	18.4
> 4 <= 4.5	0.6	0.0	0.0	0.1	0.2	6.5	2.2	0.7	10.3
> 4.5 <= 5	0.0	0.0	0.0	0.0	0.1	2.8	0.9	0.1	3.9
> 5 <= 5.5	0.0	0.0	0.0	0.0	0.1	1.6	1.0	0.1	2.8
> 5.5 <= 6	0.0	0.0	0.0	0.0	0.0	0.6	0.5	0.1	1.2
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.0	0.7
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.6
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	152.8	73.0	37.3	55.8	18.3	241.3	191.2	230.6	1000

Table 5.24 Joint probability distribution (parts per thousand) of total significant wave height and mean wave direction at peak energy during autumn (Mar-May).

Hs (m)	Wave direction (degT)								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.5	0.9	2.2	0.3	1.3	0.1	0.8	0.3	0.5	6.4
> 0.5 <= 1	13.1	10.9	8.6	11.5	1.9	11.8	11.5	15.6	84.9
> 1 <= 1.5	26.6	15.3	13.7	30.3	4.9	32.1	34.7	46.2	203.8
> 1.5 <= 2	37.6	19.8	7.8	28.6	6.2	41.9	45.0	62.4	249.3
> 2 <= 2.5	20.9	10.5	5.1	14.6	5.8	39.5	42.7	49.5	188.6
> 2.5 <= 3	10.8	2.7	2.2	8.0	3.0	33.2	30.4	26.3	116.6
> 3 <= 3.5	5.3	1.7	1.2	3.3	2.1	25.4	18.7	12.8	70.5
> 3.5 <= 4	2.3	1.4	0.2	1.3	1.4	15.4	10.6	5.6	38.2
> 4 <= 4.5	0.9	0.4	0.1	0.4	1.3	9.7	5.8	1.6	20.2
> 4.5 <= 5	0.5	0.0	0.1	0.4	0.4	5.8	2.6	0.4	10.2
> 5 <= 5.5	0.0	0.0	0.0	0.3	0.3	3.5	1.3	0.1	5.5
> 5.5 <= 6	0.0	0.0	0.0	0.2	0.2	1.9	0.8	0.0	3.1
> 6 <= 6.5	0.0	0.0	0.0	0.0	0.1	0.9	0.3	0.0	1.3
> 6.5 <= 7	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.0	0.7
> 7 <= 7.5	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2
> 7.5 <= 8	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
> 8 <= 8.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
> 8.5 <= 9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Total	118.9	64.9	39.3	100.2	27.8	222.5	205.2	221.0	1000

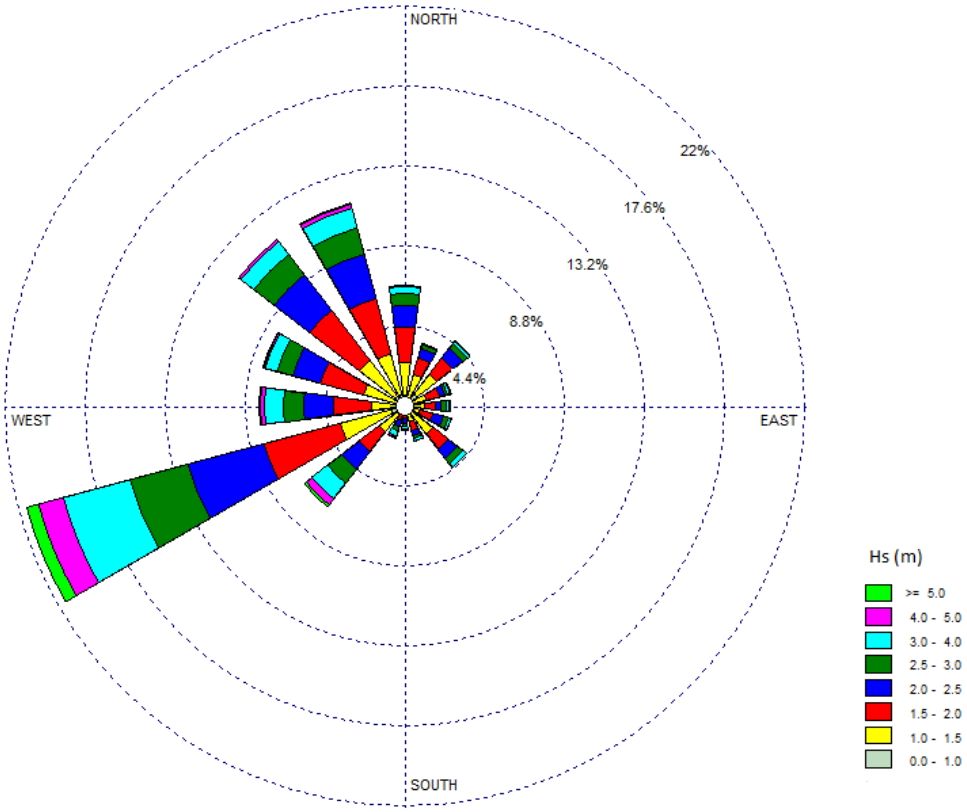

Figure 5.1 Annual total significant wave rose.

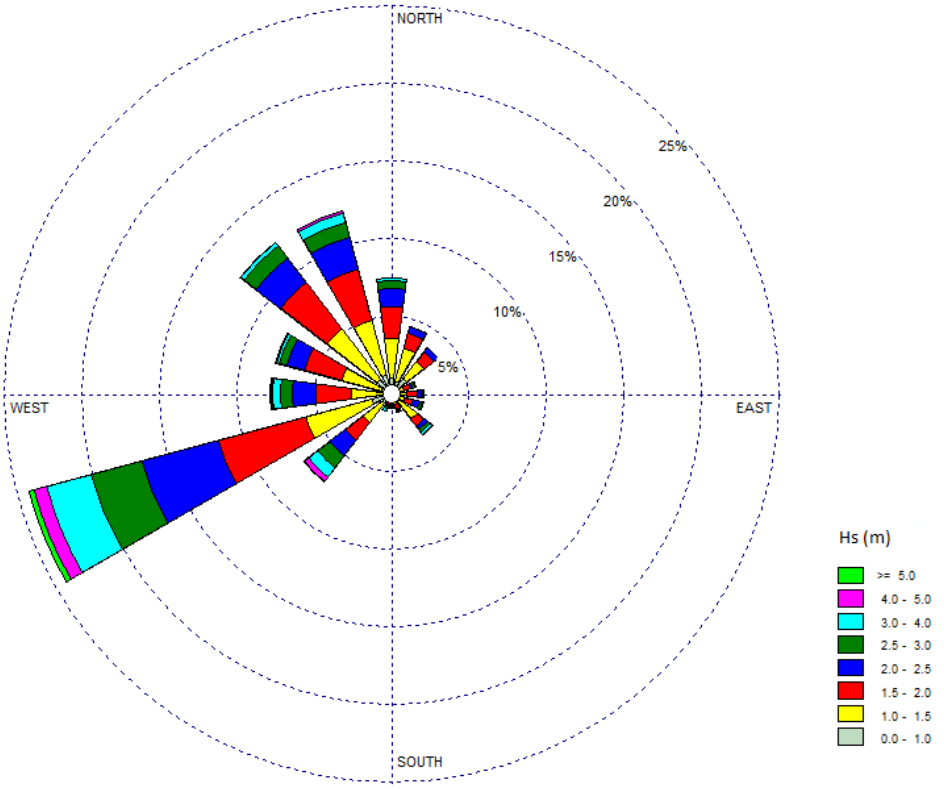

Figure 5.2 Summer (Dec-Feb) total significant wave rose.

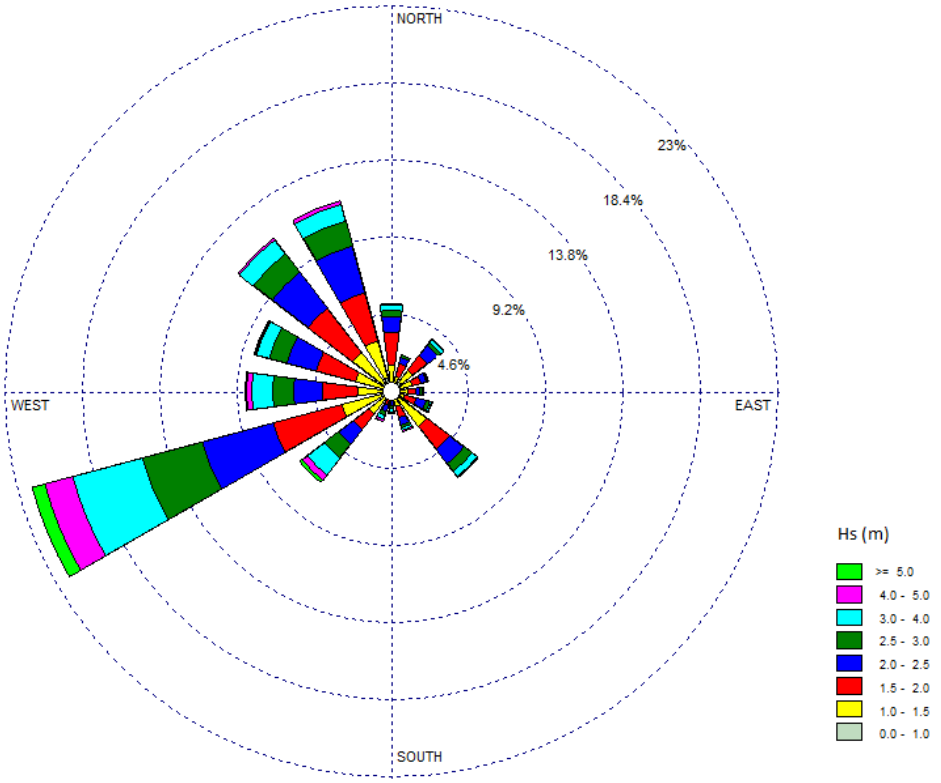

Figure 5.3 Autumn (Mar-May) total significant wave rose.

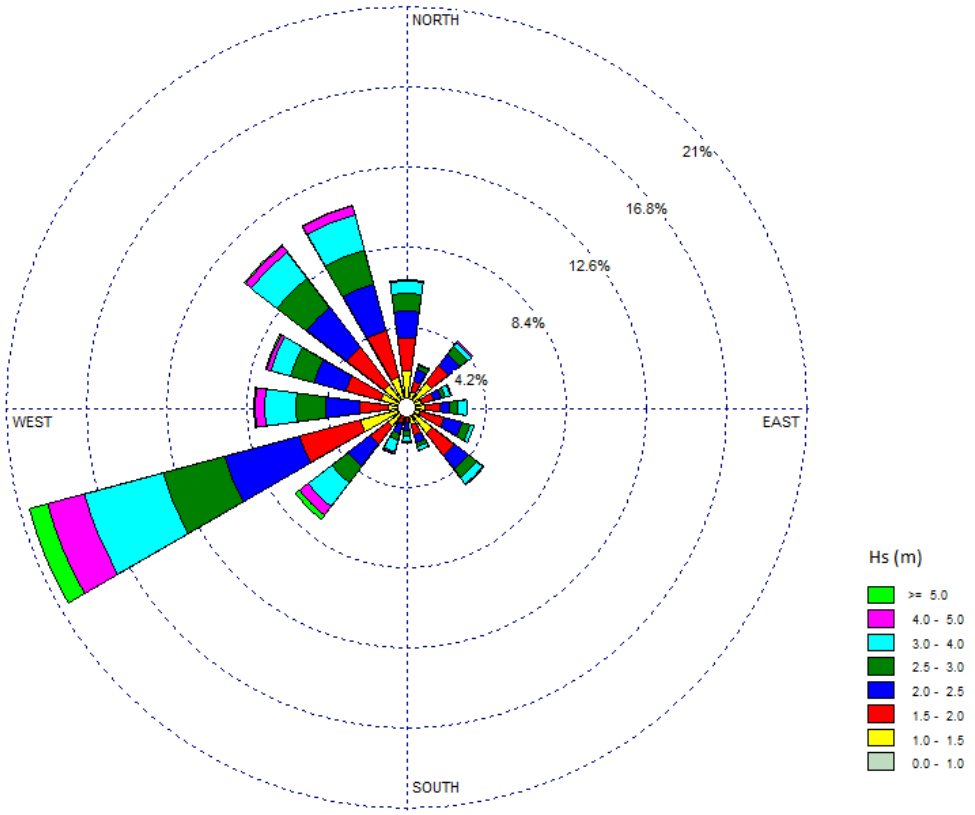

Figure 5.4 Winter (Jun-Aug) total significant wave rose.

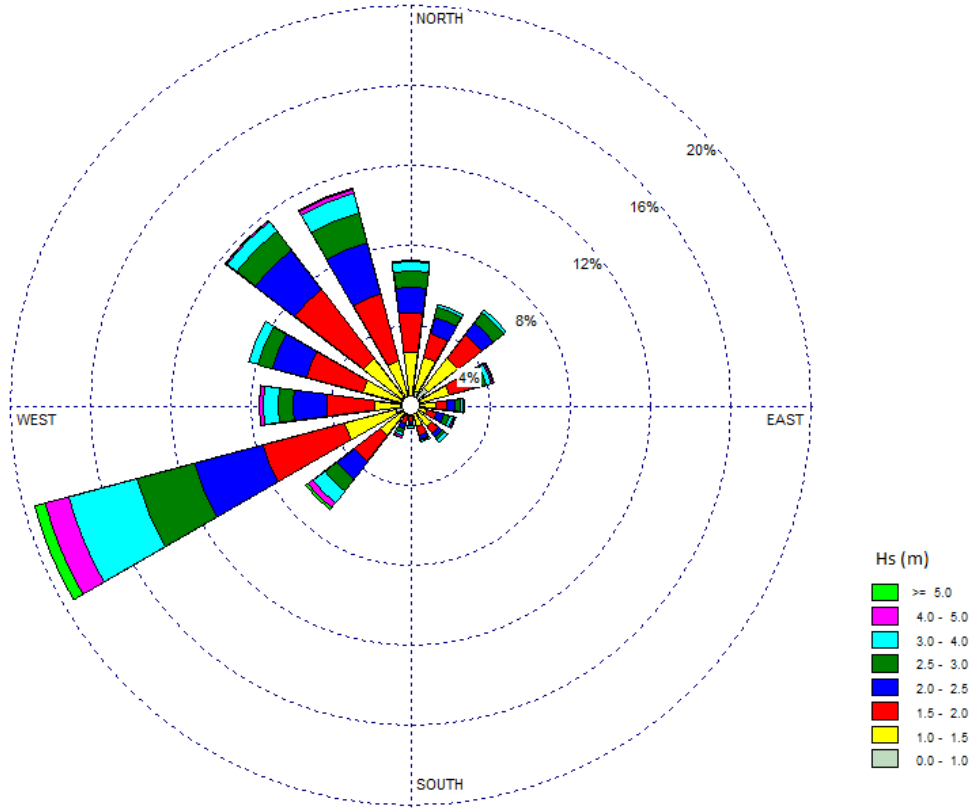

Figure 5.5 Spring (Sep-Nov) total significant wave rose.

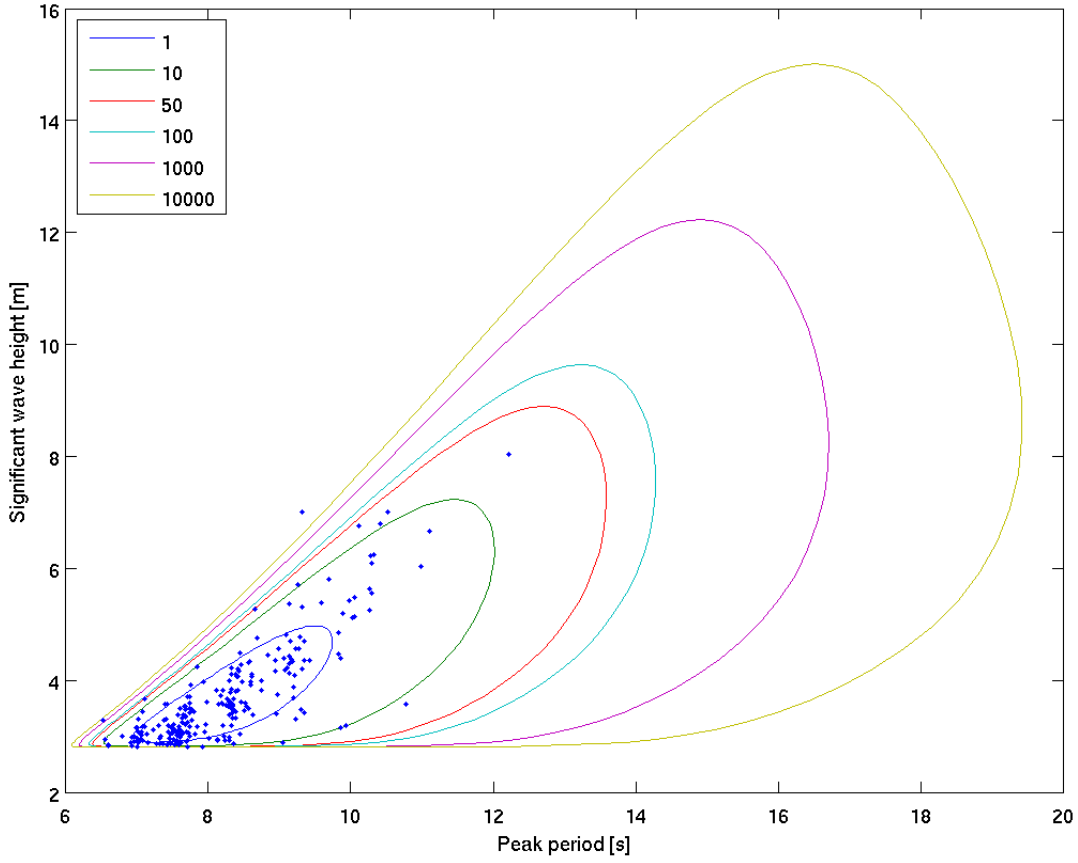

Table 5.25 Annual Return Period Values of total significant wave height.

RPV [m]	Directional sector (degT)								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Omni**
1	4.16	3.24	3.34	3.94	4.33	6.37	6.19	4.76	6.72
10	5.27	4.51	5.20	5.41	6.08	7.97	7.96	6.50	8.62
50	5.92	5.61	6.19	6.36	6.89	8.81	8.91	7.84	9.84
100	6.17	6.16	6.56	6.75	7.17	9.12	9.62	8.44	10.34
1000	6.90	8.30	7.56	7.95	7.85	9.95	10.21	10.61	11.89
10000	7.49	11.08	8.29	9.05	8.27	10.55	10.91	13.01	13.30

6. CURRENT STATISTICS

Summary statistics of the surface currents are shown in Table 6.1. Directional distributions are presented in Tables 6.2-6.6 and as current roses in Figures 6.1-6.5. Note that directions for currents are going to.

Mean current speeds are in the range 10 – 16 cm/s, with a hindcast maxima of 55 cm/s. Directionality is strongly dominated by flow to the NW, consistent with a geostrophic balance with SW sector winds. However, an interesting feature is the reduction of mean and maximum flows during the slightly windier winter half of the year; this is possibly caused by the local wind stress intermittently opposing the current flow over the short timescales of passing low pressure systems.

Table 6.1 Surface current speed statistics.

***Current speed* (m/s)**	**Statistic**					
	Mean	**Median**	**P90**	**P95**	**P99**	**Max**
January	0.155	0.144	0.264	0.299	0.372	0.533
February	0.150	0.139	0.261	0.295	0.374	0.497
March	0.139	0.130	0.242	0.277	0.336	0.495
April	0.119	0.110	0.209	0.236	0.310	0.443
May	0.107	0.098	0.187	0.215	0.276	0.422
June	0.105	0.098	0.182	0.210	0.281	0.442
July	0.106	0.100	0.183	0.211	0.265	0.388
August	0.105	0.100	0.181	0.208	0.262	0.368
September	0.107	0.100	0.188	0.216	0.270	0.396
October	0.119	0.113	0.206	0.235	0.298	0.362
November	0.126	0.119	0.218	0.246	0.299	0.435
December	0.144	0.135	0.246	0.283	0.351	0.546
1989	0.127	0.116	0.223	0.267	0.316	0.379
1990	0.133	0.124	0.230	0.261	0.340	0.493
1991	0.124	0.117	0.208	0.246	0.306	0.414
1992	0.122	0.110	0.221	0.248	0.313	0.430
1993	0.124	0.115	0.219	0.250	0.320	0.402
1994	0.120	0.109	0.209	0.245	0.318	0.431
1995	0.125	0.115	0.219	0.253	0.314	0.435
1996	0.128	0.119	0.225	0.255	0.321	0.422
1997	0.124	0.118	0.214	0.245	0.305	0.412
1998	0.125	0.115	0.222	0.262	0.327	0.414
1999	0.126	0.115	0.224	0.259	0.320	0.415
2000	0.128	0.118	0.221	0.267	0.344	0.463
2001	0.116	0.106	0.203	0.237	0.297	0.497
2002	0.120	0.111	0.201	0.240	0.316	0.412
2003	0.121	0.107	0.216	0.258	0.342	0.533
2004	0.119	0.107	0.215	0.252	0.321	0.388
2005	0.117	0.105	0.206	0.241	0.315	0.424
2006	0.122	0.112	0.211	0.246	0.312	0.525
2007	0.123	0.113	0.214	0.244	0.309	0.432
2008	0.118	0.105	0.216	0.254	0.320	0.546
2009	0.128	0.120	0.225	0.262	0.353	0.409
2010	0.125	0.115	0.222	0.260	0.336	0.437
All	0.123	0.113	0.217	0.252	0.322	0.55

Table 6.2 Annual joint probability distribution (parts per thousand) of surface current speed and current direction.

***Current speed* (m/s)**	**Current direction (going to) (degT)**								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.05	21.8	18.1	14.7	12.6	12.0	11.5	18.4	21.2	130.3
> 0.05 <= 0.1	64.1	41.4	27.7	18.0	14.8	18.5	38.5	67.1	290.1
> 0.1 <= 0.15	72.9	39.0	23.1	12.2	8.1	11.9	32.6	75.8	275.6
> 0.15 <= 0.2	53.1	22.1	11.6	5.2	3.0	4.9	16.6	50.8	167.3
> 0.2 <= 0.25	28.0	10.4	5.2	2.8	0.8	1.2	7.5	28.5	84.4
> 0.25 <= 0.3	12.7	4.4	1.9	0.7	0.4	0.4	2.2	12.3	35.0
> 0.3 <= 0.35	4.6	1.6	0.3	0.1	0.1	0.2	0.7	4.3	11.9
> 0.35 <= 0.4	1.6	0.4	0.1	0.0	0.0	0.1	0.3	1.2	3.7
> 0.4 <= 0.45	0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.4	1.3
> 0.45 <= 0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
> 0.5 <= 0.55	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	259.5	137.6	84.7	51.6	39.2	48.7	116.8	261.7	1000

Table 6.3 Joint probability distribution (parts per thousand) of surface current speed and current direction during summer (Dec-Feb).

***Current speed* (m/s)**	**Current direction (going to) (degT)**								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.05	11.0	10.6	10.2	7.9	8.7	9.1	11.5	10.8	79.8
> 0.05 <= 0.1	41.3	30.5	21.4	17.4	16.4	22.0	28.0	38.9	215.9
> 0.1 <= 0.15	55.4	34.5	22.7	14.5	12.1	19.7	37.9	58.8	255.6
> 0.15 <= 0.2	55.9	27.7	15.6	8.4	5.7	8.8	26.7	53.9	202.7
> 0.2 <= 0.25	37.4	16.9	9.7	5.0	1.9	2.9	16.3	42.2	132.3
> 0.25 <= 0.3	21.8	10.6	4.8	1.8	0.9	1.1	6.0	23.6	70.6
> 0.3 <= 0.35	8.2	3.3	1.4	0.4	0.4	0.9	2.1	11.5	28.2
> 0.35 <= 0.4	4.8	0.8	0.5	0.1	0.0	0.4	0.8	3.3	10.7
> 0.4 <= 0.45	1.6	0.4	0.1	0.1	0.0	0.0	0.0	1.3	3.5
> 0.45 <= 0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.3
> 0.5 <= 0.55	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.4
Total	237.4	135.7	86.4	55.6	46.1	64.9	129.4	244.5	1000

Table 6.4 Joint probability distribution (parts per thousand) of surface current speed and current direction during autumn (Mar-May).

***Current speed* (m/s)**	**Current direction (going to) (degT)**								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.05	24.3	19.8	12.5	12.1	12.4	11.6	18.5	20.9	132.1
> 0.05 <= 0.1	63.7	41.9	30.1	17.2	16.4	18.3	43.7	70.4	301.7
> 0.1 <= 0.15	71.1	41.0	21.5	10.5	6.4	11.5	33.6	75.5	271.1
> 0.15 <= 0.2	53.5	24.3	11.9	3.0	2.1	4.7	16.4	51.3	167.2
> 0.2 <= 0.25	28.4	10.6	4.2	2.1	1.0	1.1	6.3	27.8	81.5
> 0.25 <= 0.3	12.7	2.8	0.7	0.4	0.5	0.4	1.5	11.7	30.7
> 0.3 <= 0.35	5.8	1.7	0.0	0.0	0.0	0.0	0.2	3.6	11.3
> 0.35 <= 0.4	1.1	0.6	0.0	0.0	0.0	0.0	0.2	0.6	2.5
> 0.4 <= 0.45	0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.5	1.4
> 0.45 <= 0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
> 0.5 <= 0.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	261.4	142.8	81.0	45.3	38.8	47.6	120.4	262.4	1000

Table 6.5 Joint probability distribution (parts per thousand) of surface current speed and current direction during Winter (Jun-Aug).

***Current speed* (m/s)**	**Current direction (going to) (degT)**								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.05	29.0	23.6	18.3	14.9	13.8	13.8	25.4	28.8	167.6
> 0.05 <= 0.1	83.7	46.8	29.5	16.2	10.9	14.1	44.3	93.4	338.9
> 0.1 <= 0.15	90.9	37.5	24.0	10.1	5.7	6.9	27.9	90.0	293.0
> 0.15 <= 0.2	52.6	14.2	5.6	2.7	1.5	2.5	9.9	47.2	136.2
> 0.2 <= 0.25	18.9	4.2	2.3	1.7	0.2	0.1	2.3	17.3	47.0
> 0.25 <= 0.3	6.1	1.1	0.2	0.2	0.0	0.1	0.1	6.1	13.9
> 0.3 <= 0.35	1.4	0.2	0.0	0.0	0.0	0.0	0.0	0.9	2.5
> 0.35 <= 0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
> 0.4 <= 0.45	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
> 0.45 <= 0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 0.5 <= 0.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	282.9	127.6	79.9	45.8	32.1	37.5	109.9	283.8	1000

Table 6.6 Joint probability distribution (parts per thousand) of surface current speed and current direction during spring (Sep-Nov).

***Current speed* (m/s)**	**Current direction (going to) (degT)**								
	337.5 to 22.5	**22.5 to 67.5**	**67.5 to 112.5**	**112.5 to 157.5**	**157.5 to 202.5**	**202.5 to 247.5**	**247.5 to 292.5**	**292.5 to 337.5**	**Total**
> 0 <= 0.05	22.7	18.5	17.9	15.5	13.1	11.6	17.9	24.0	141.2
> 0.05 <= 0.1	67.3	46.1	29.6	21.2	15.5	19.6	37.8	65.1	302.2
> 0.1 <= 0.15	73.8	43.0	24.1	13.6	8.1	9.5	31.0	78.7	281.8
> 0.15 <= 0.2	50.4	22.4	13.6	6.7	3.0	3.7	13.7	50.8	164.3
> 0.2 <= 0.25	27.6	10.1	4.5	2.4	0.1	0.9	5.2	27.0	77.8
> 0.25 <= 0.3	10.4	3.4	1.9	0.2	0.1	0.1	1.4	8.0	25.5
> 0.3 <= 0.35	3.1	1.0	0.0	0.0	0.0	0.1	0.4	1.4	6.0
> 0.35 <= 0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.6	1.0
> 0.4 <= 0.45	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
> 0.45 <= 0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 0.5 <= 0.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	255.6	144.6	91.6	59.6	39.9	45.5	107.5	255.6	1000

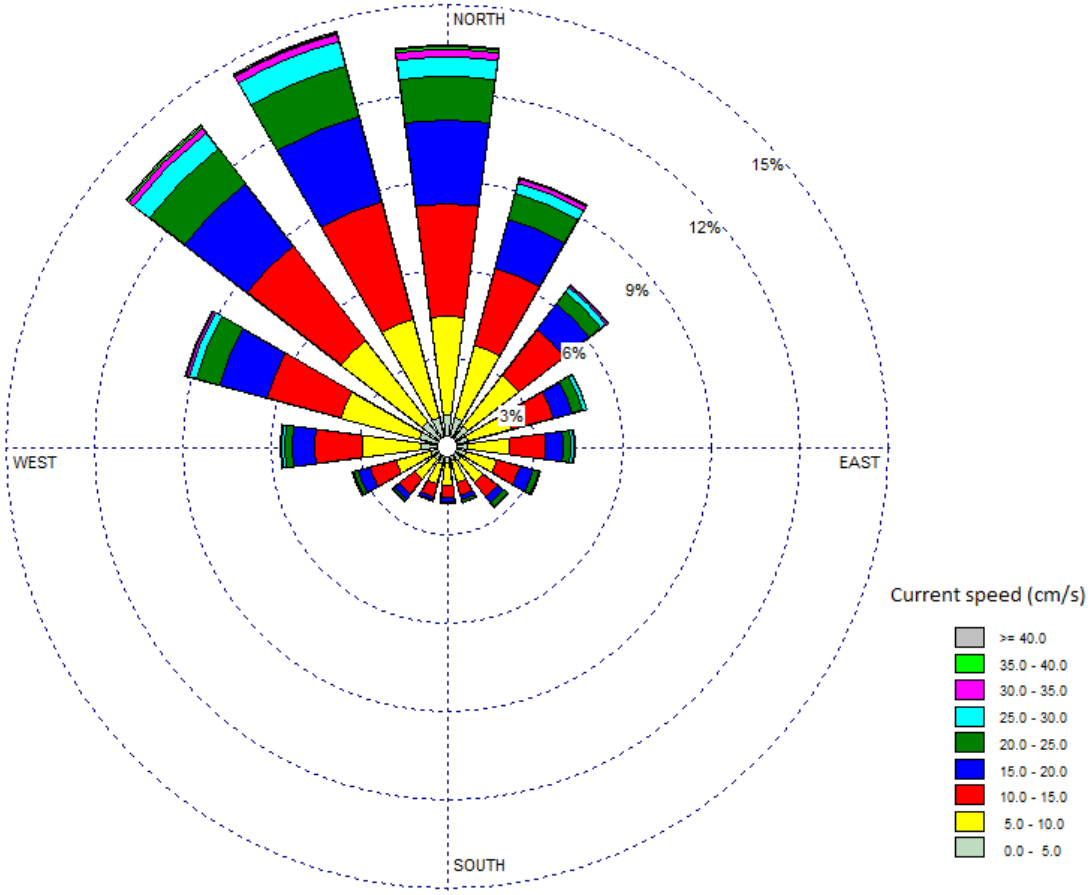

Figure 6.1 Annual surface current rose.

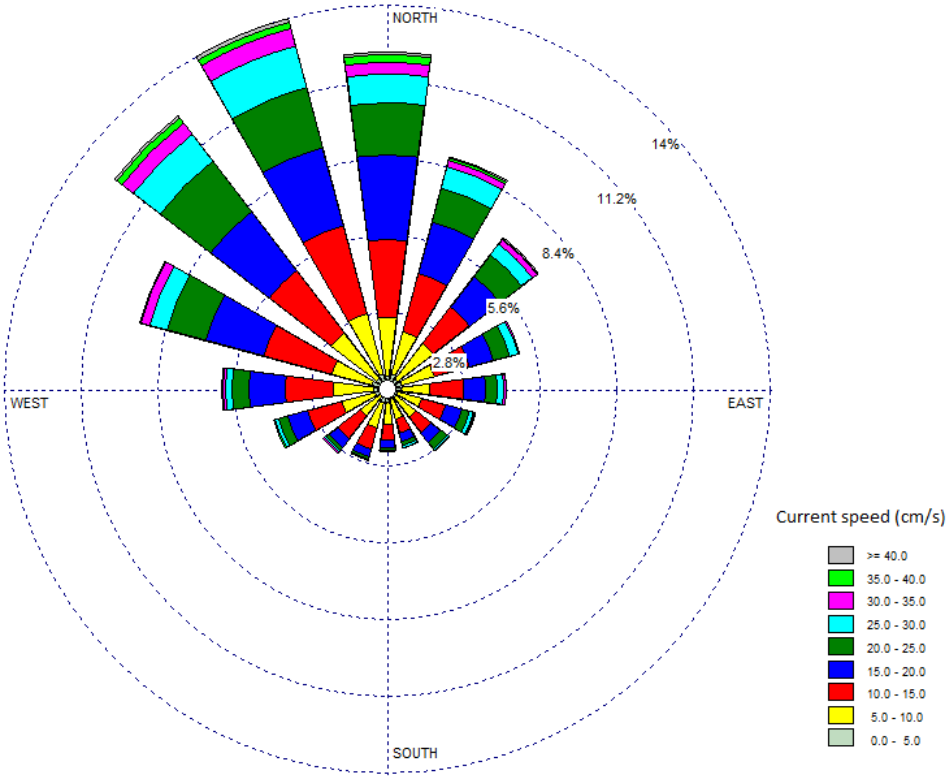

Figure 6.2 Summer (Dec-Feb) surface current rose.

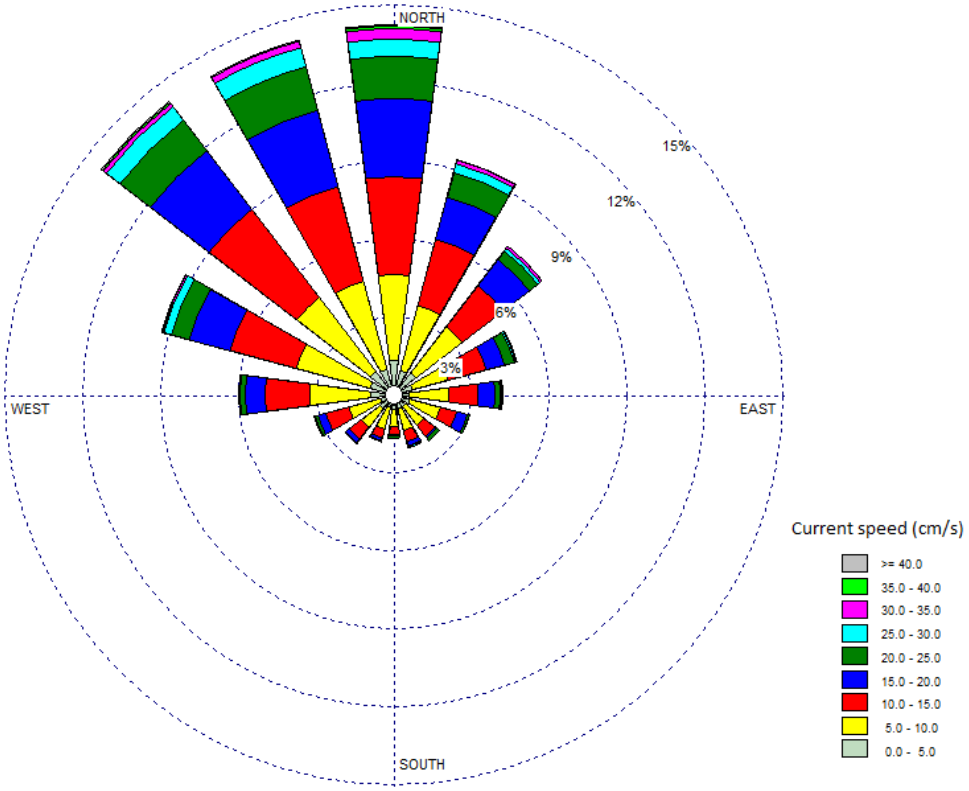

Figure 6.3 Autumn (Mar-May) surface current rose.

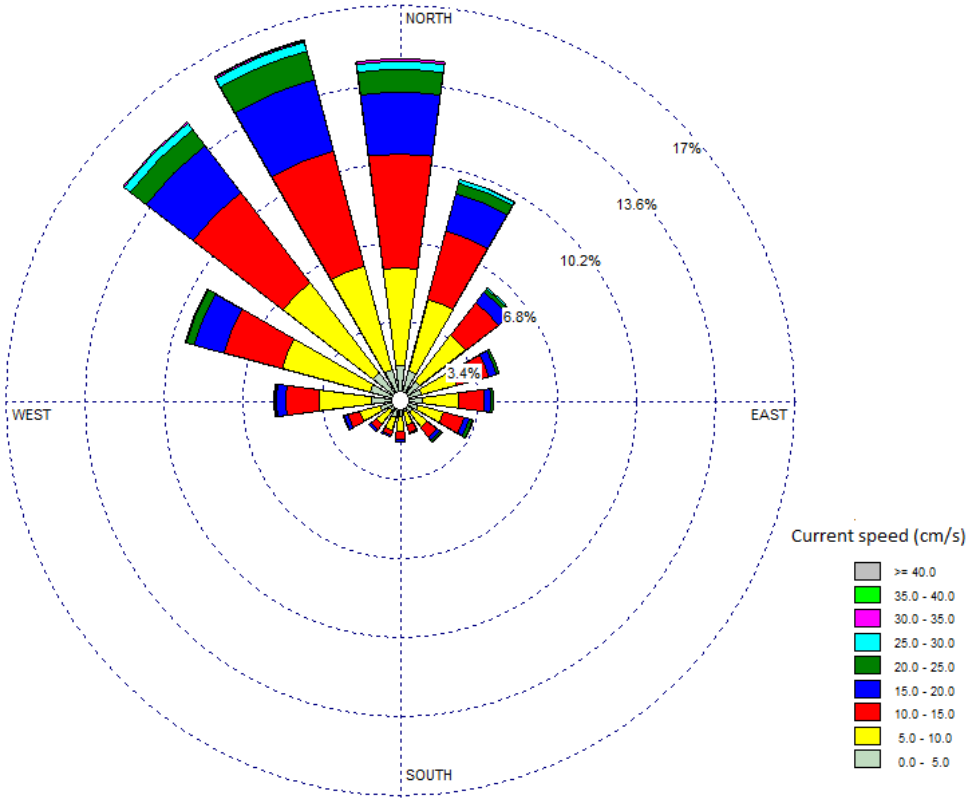

Figure 6.4 Winter (Jun-Aug) surface current rose.

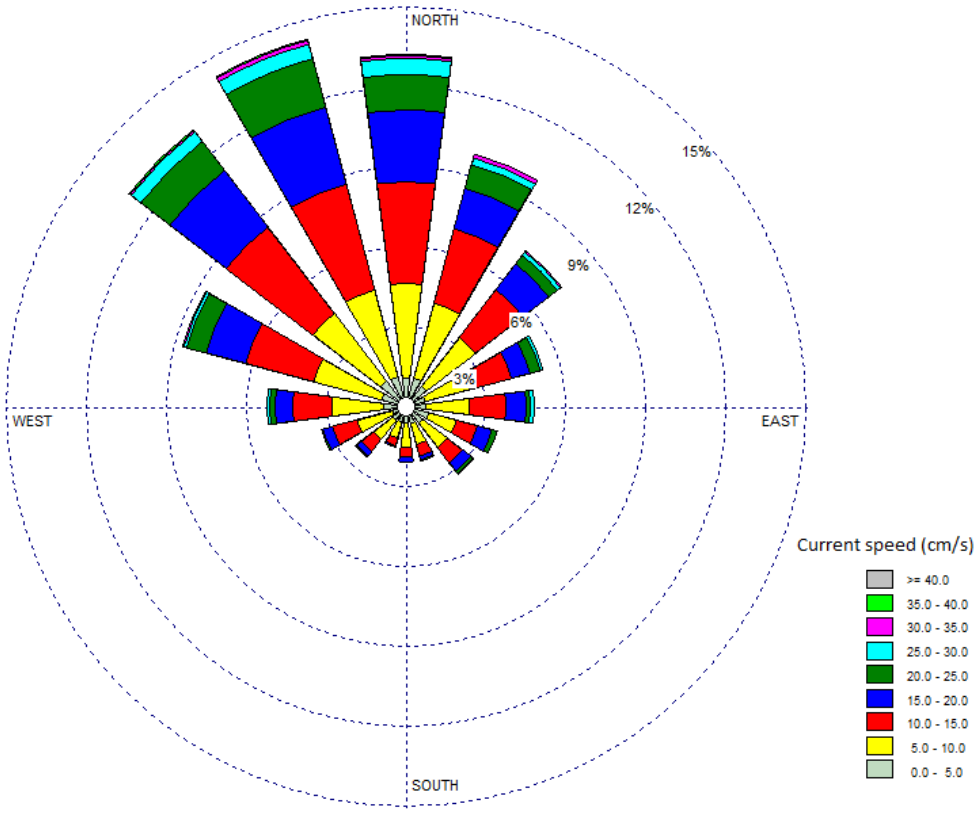

Figure 6.5 Spring (Sep-Nov) surface current rose.

7. COINCIDENCE OF WINDS AND WAVES

The coincidence of wave and windspeed shows some correlation (Figure 7.1) as would be expected for sea states with locally generated conditions. Figure 7.2 and Table 7.2 show a consistent pattern with respect to directionality, with larger sea states aligned with the wind vector.

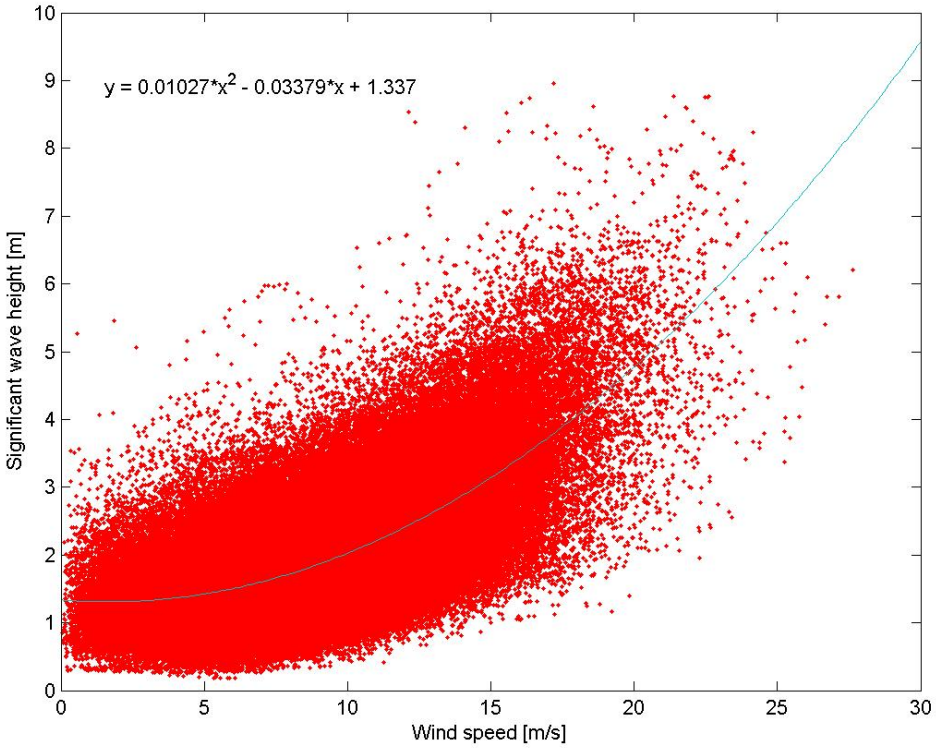

Figure 7.1 Total significant wave height versus wind speed. The quadratic best fit is shown.

Table 7.1 Probability of non-exceedance of windspeed co-incident with total significant wave height.

Hs (m)	Non-exceedance probability windspeed (m/s)					
	< 5	< 10	< 15	< 20	< 25	< 30
> 0 <= 1	36.42	95.95	100.00	100.00	100.00	100.00
> 1 <= 2	15.89	76.39	99.30	100.00	100.00	100.00
> 2 <= 3	5.00	45.96	95.38	99.90	100.00	100.00
> 3 <= 4	1.40	17.64	80.56	99.40	100.00	100.00
> 4 <= 5	0.37	4.04	48.53	96.69	100.00	100.00
> 5 <= 6	0.00	2.56	21.79	88.46	100.00	100.00
> 6 <= 7	0.00	0.00	10.00	75.00	100.00	100.00
> 7 <= 8	0.00	0.00	0.00	33.33	100.00	100.00
> 8 <= 9	0.00	0.00	0.00	50.00	100.00	100.00
Total	12.58	60.66	94.11	99.63	99.98	100.00

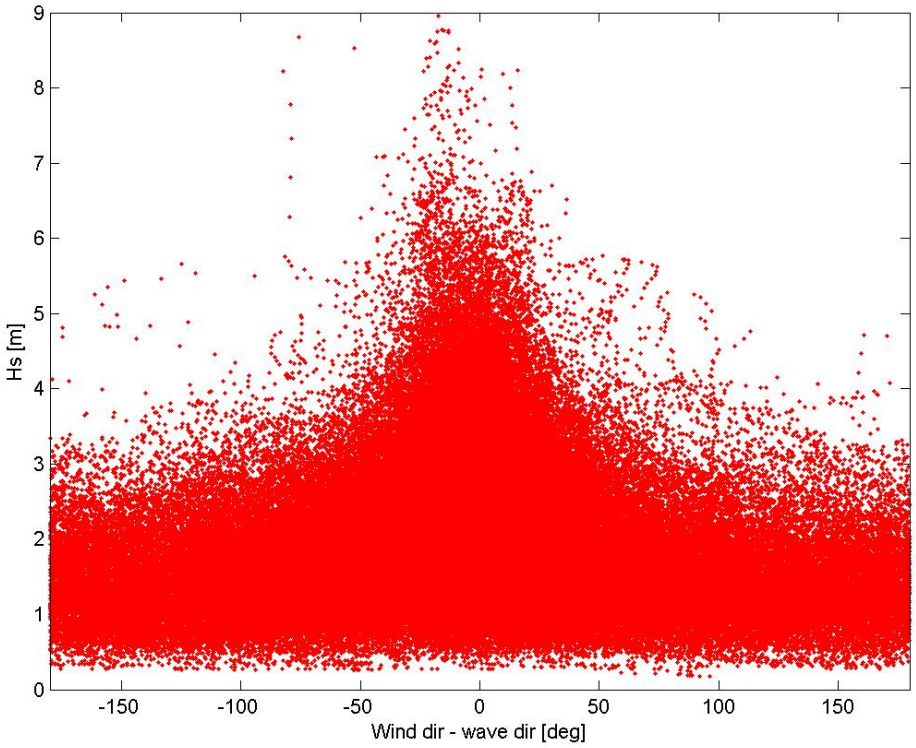

Figure 7.2 Total significant wave height versus the difference between wind direction and total peak spectral wave direction.

Table 7.2 Probability of non-exceedance (%) of total significant wave height co-incident with the difference between wind direction and total peak spectral wave direction.

Wind direction minus total peak spectral wave direction (deg)	Total significant wave height (m)								
	< 1	< 2	< 3	< 4	< 5	< 6	< 7	< 8	< 9
> -180 <= -135	21.26	82.24	98.36	99.77	100	100	100	100	100
> -135 <= -90	17.97	77.12	97.22	99.84	100	100	100	100	100
> -90 <= -45	11.47	66.57	94.22	99.22	99.8	100	100	100	100
> -45 <= 0	4.56	42.95	78.23	93.09	97.95	99.41	99.87	99.97	100
> 0 <= 45	5.63	49.04	82.51	95.5	98.9	99.81	100	100	100
> 45 <= 90	14.27	72.66	94.72	98.92	99.64	100	100	100	100
> 90 <= 135	21.14	79.92	97.04	99.58	100	100	100	100	100
> 135 <= 180	21.78	83.73	98.16	100	100	100	100	100	100
Total	9.39	56.83	86.24	96.2	98.93	99.72	99.92	99.95	100

8. TIME SERIES PLOTS

The full set of time series plots of significant wave height, peak spectral period, mean wave direction and wind speed/direction is presented in Figures 8.1-8.22.

9. SUMMARY

The metocean conditions for a location in the Southern Atlantic have been summarised from a 22-year hindcast data set of waves, winds and currents.

The data indicate an energetic climate with high wind speeds and periods of large waves. In summary:

- Mean wind speeds are relatively high in the range 8.6-9.5 m/s with hindcast maxima close to 28 m/s.
- Winds are predominantly from the westerly sector.
- Mean wave heights are around 2.0 m with a hindcast maximum of 8.96 m.
- Wave directionality is dominated by the westerly sector.
- Sea state tends to be dominated by locally generated sea, particularly for higher energy events.
- Mean Surface currents are moderate in the range 10-16 cm/s, and with a hindcast maximum of 55 cm/s
- Currents are predominantly to the NW and show reduced mean and maximum speeds during the winter months.
- Overall metocean conditions are similar throughout the year, in particular with respect to directionality.
- Inter-annual variablity of wave conditions is of the order of 10% with respect to mean significant wave height; 99% exceedance values vary by up to 30% of the mean.

As mentioned in Section 2.1.1, no bias correction has been carried out, and wave statistics are therefore likely to be low. A conservative modifier might be to add 0.25 m to all significant wave height statistics; a more exact bias correction would ideally utilise site specific data.

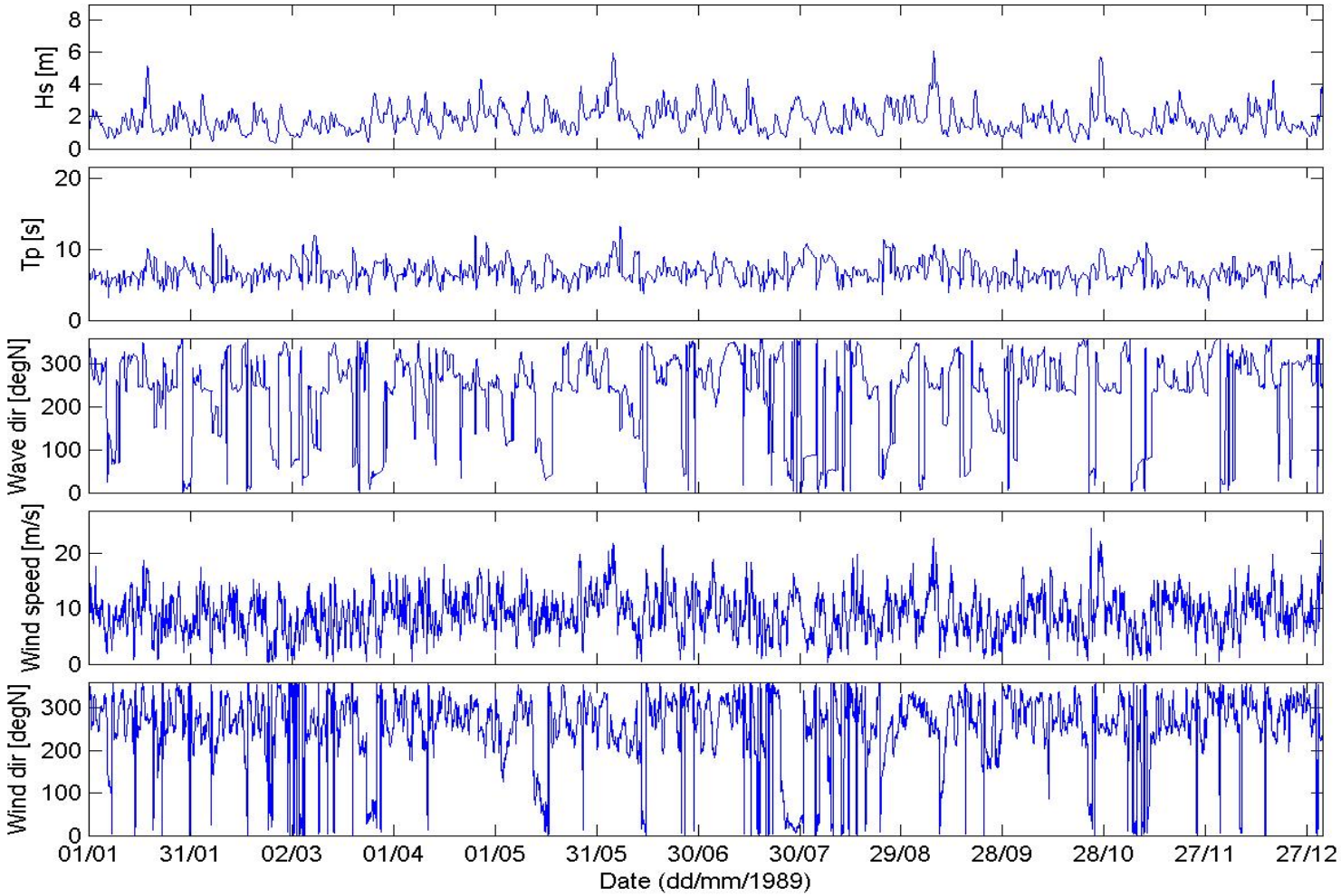

Figure 9.1 Time series of waves and winds during 1989.

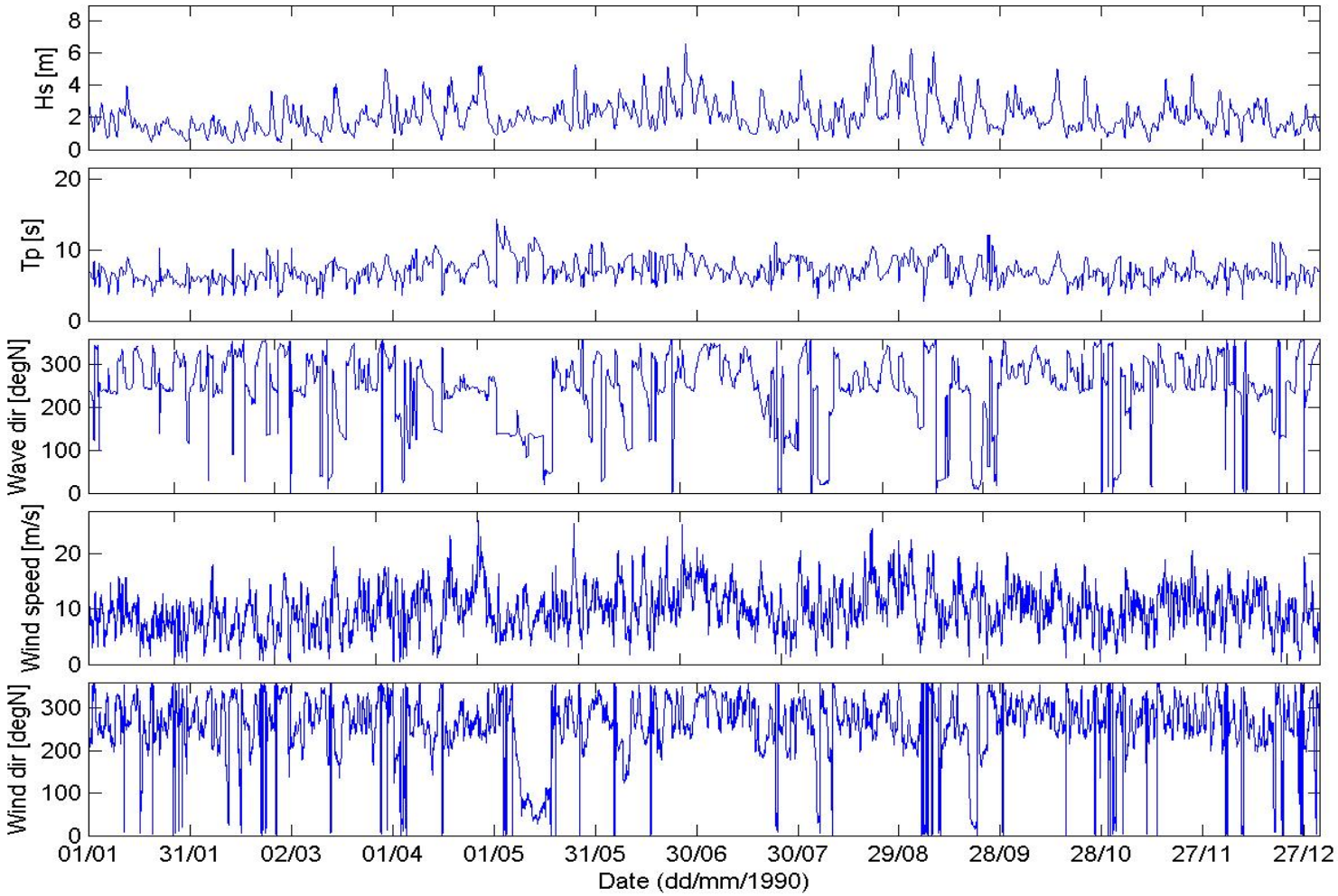

Figure 9.2 Time series plot of waves and winds during 1990.

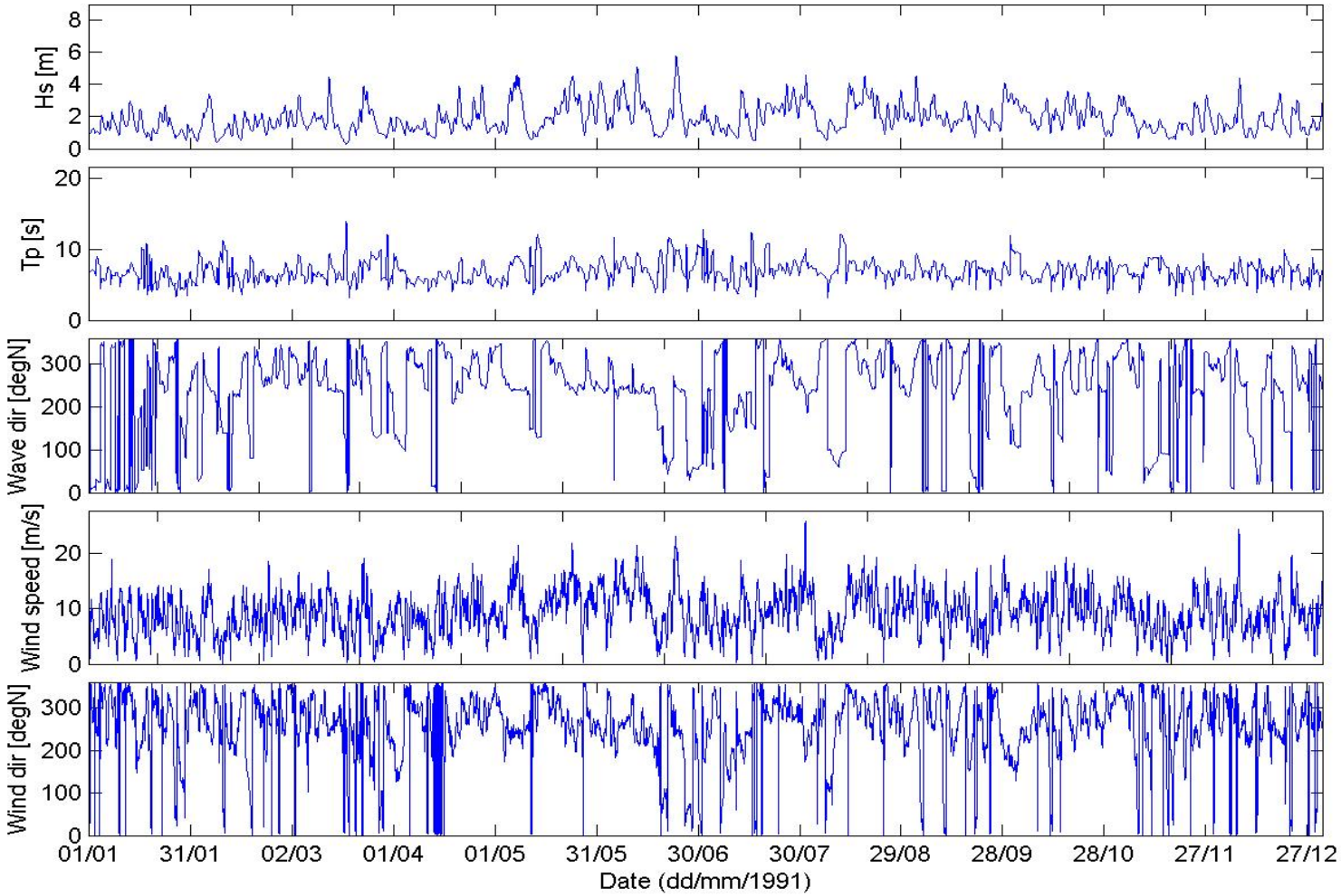

Figure 9.3 Time series plot of waves and winds during 1991.

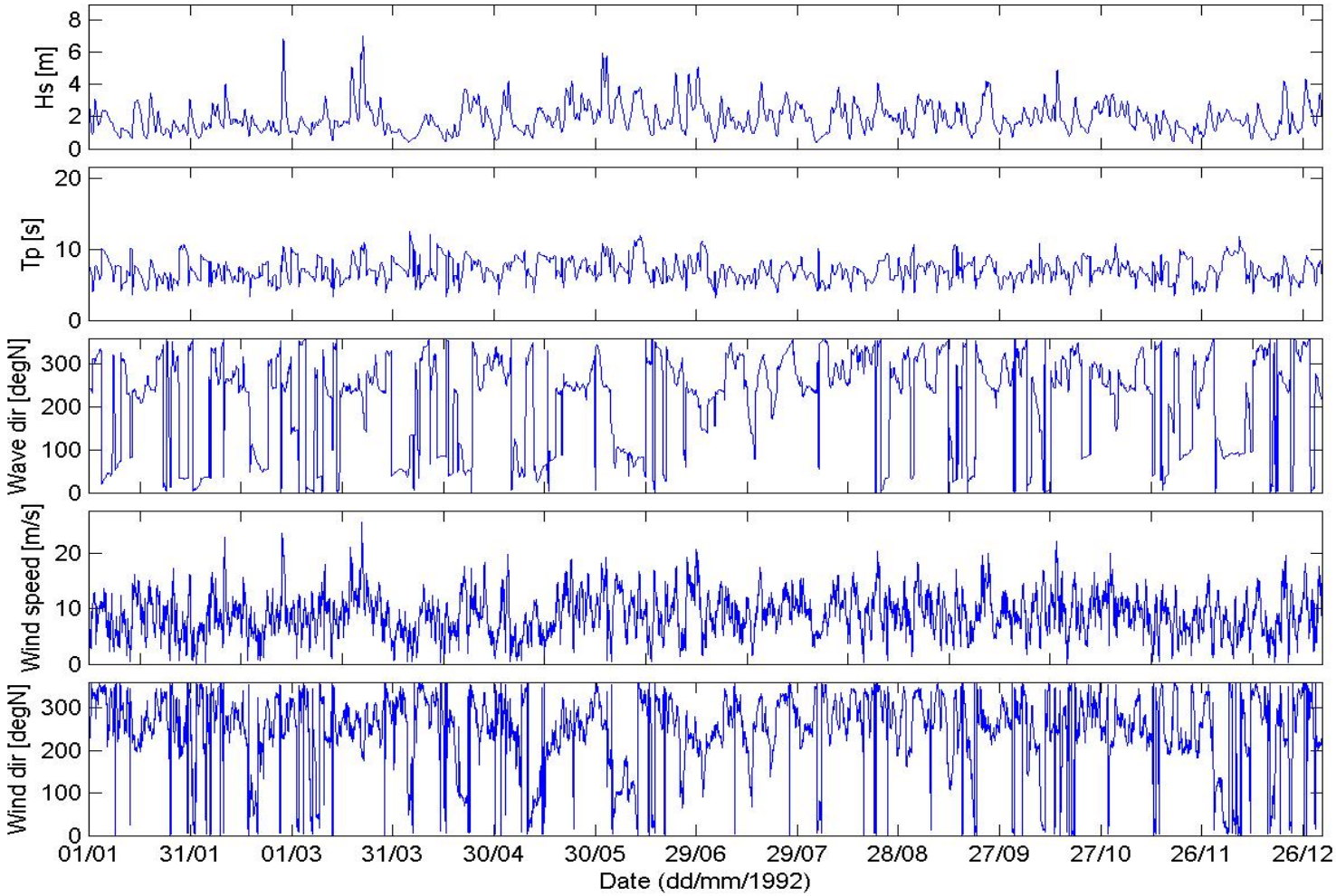

Figure 9.4 Time series plot of waves and winds during 1992.

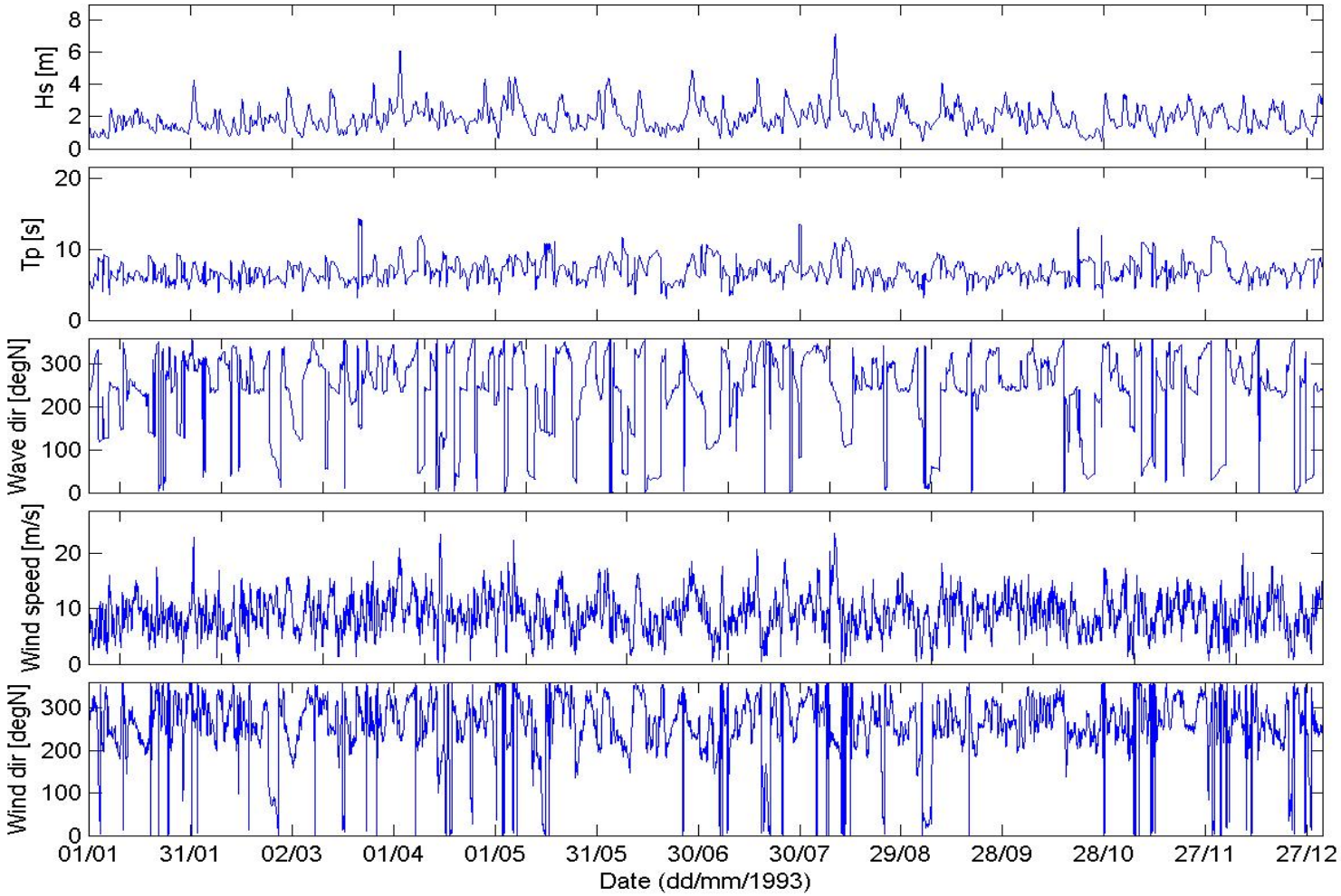

Figure 9.5 Time series plot of waves and winds during 1993.

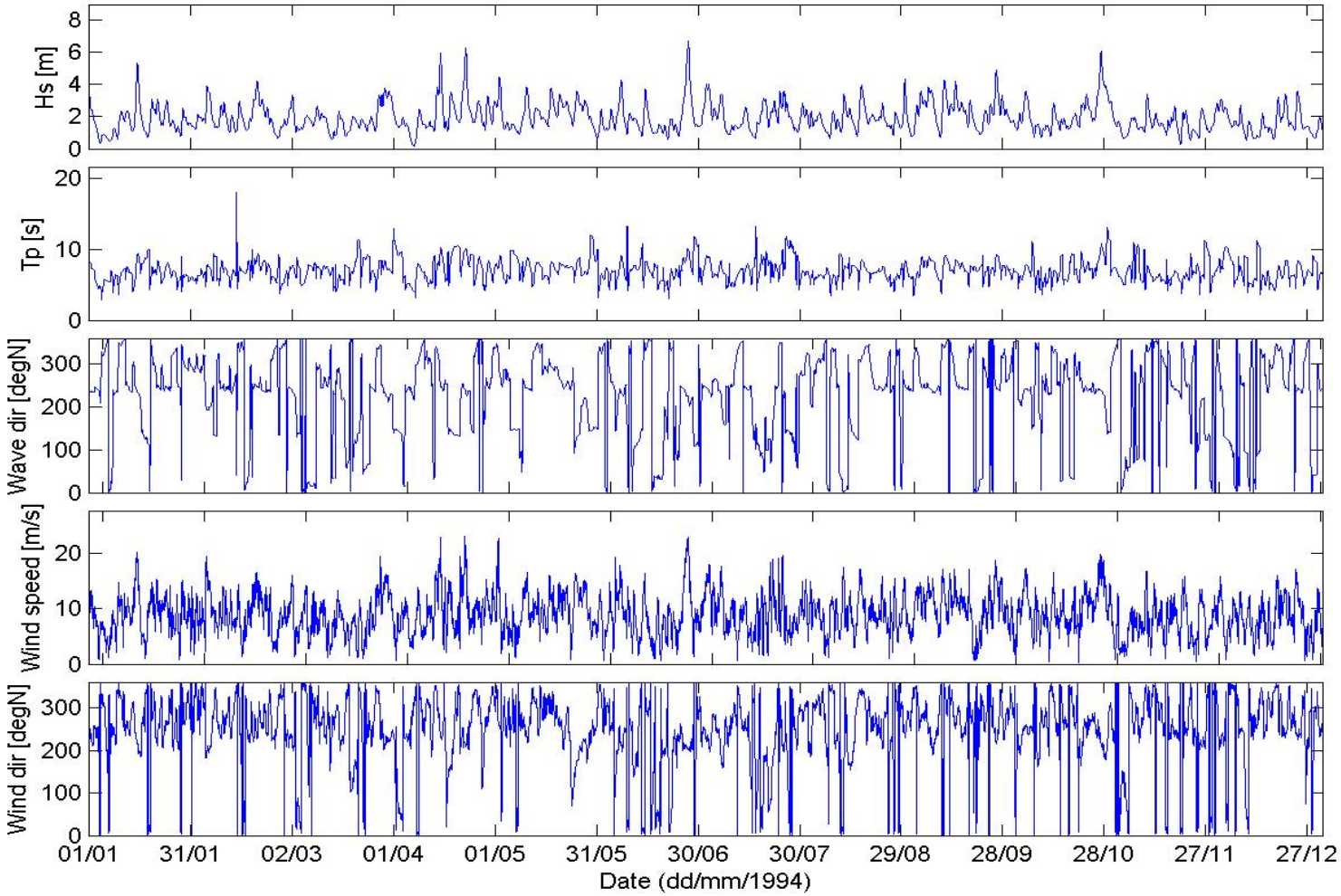

Figure 9.6 Time series plot of waves and winds during 1994.

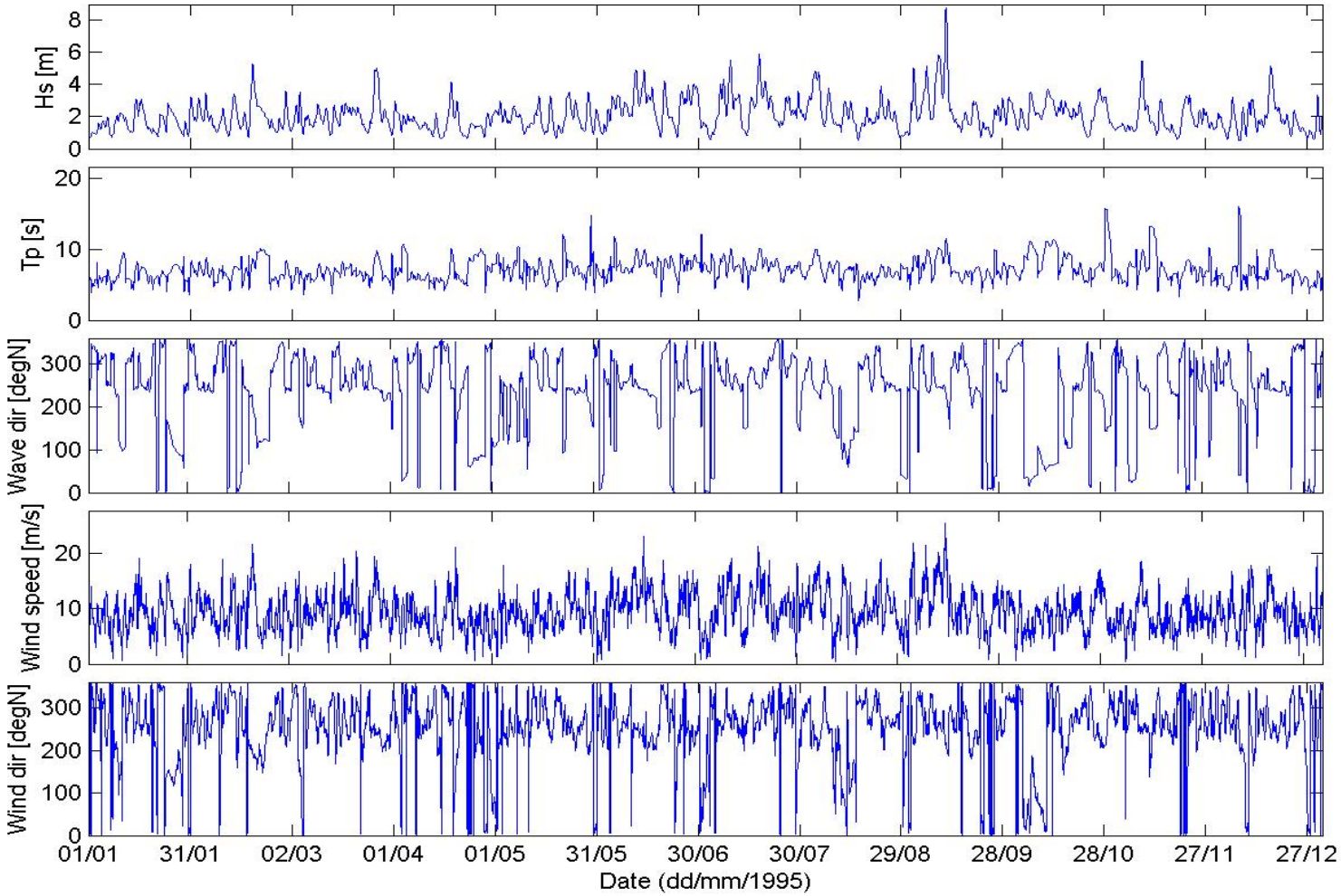

Figure 9.7 Time series plot of waves and winds during 1995.

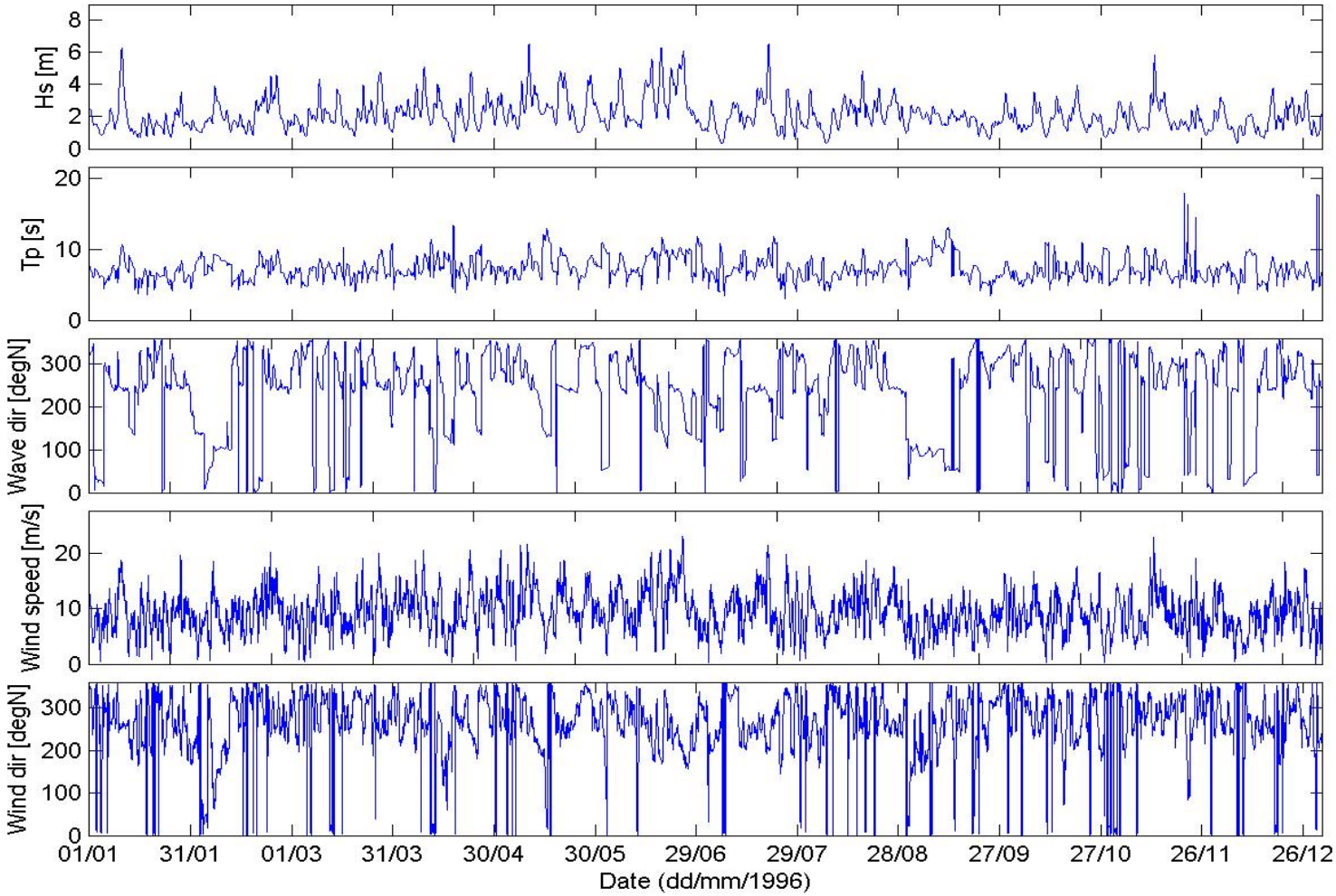

Figure 9.8 Time series plot of waves and winds during 1996.

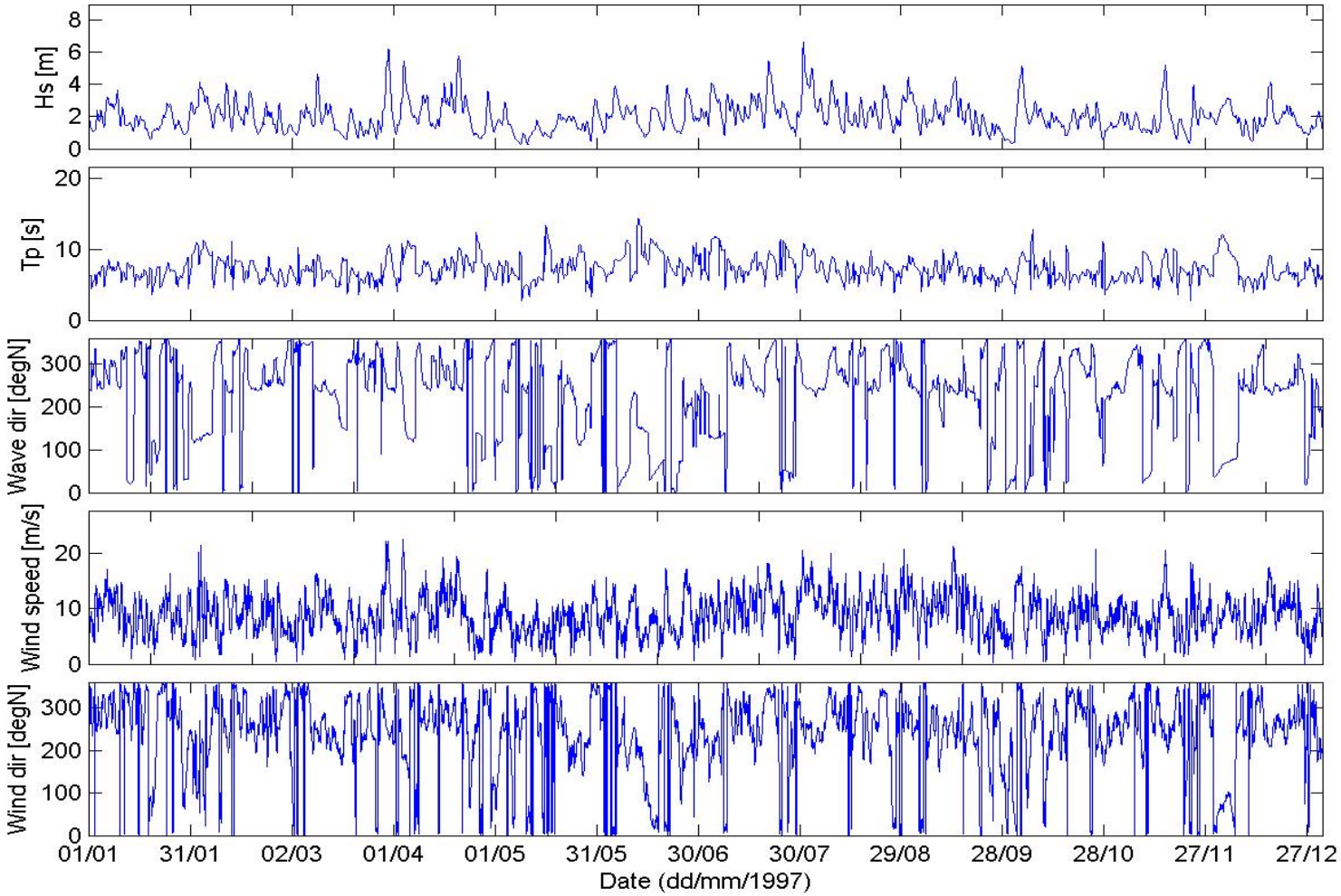

Figure 9.9 Time series plot of waves and winds during 1997.

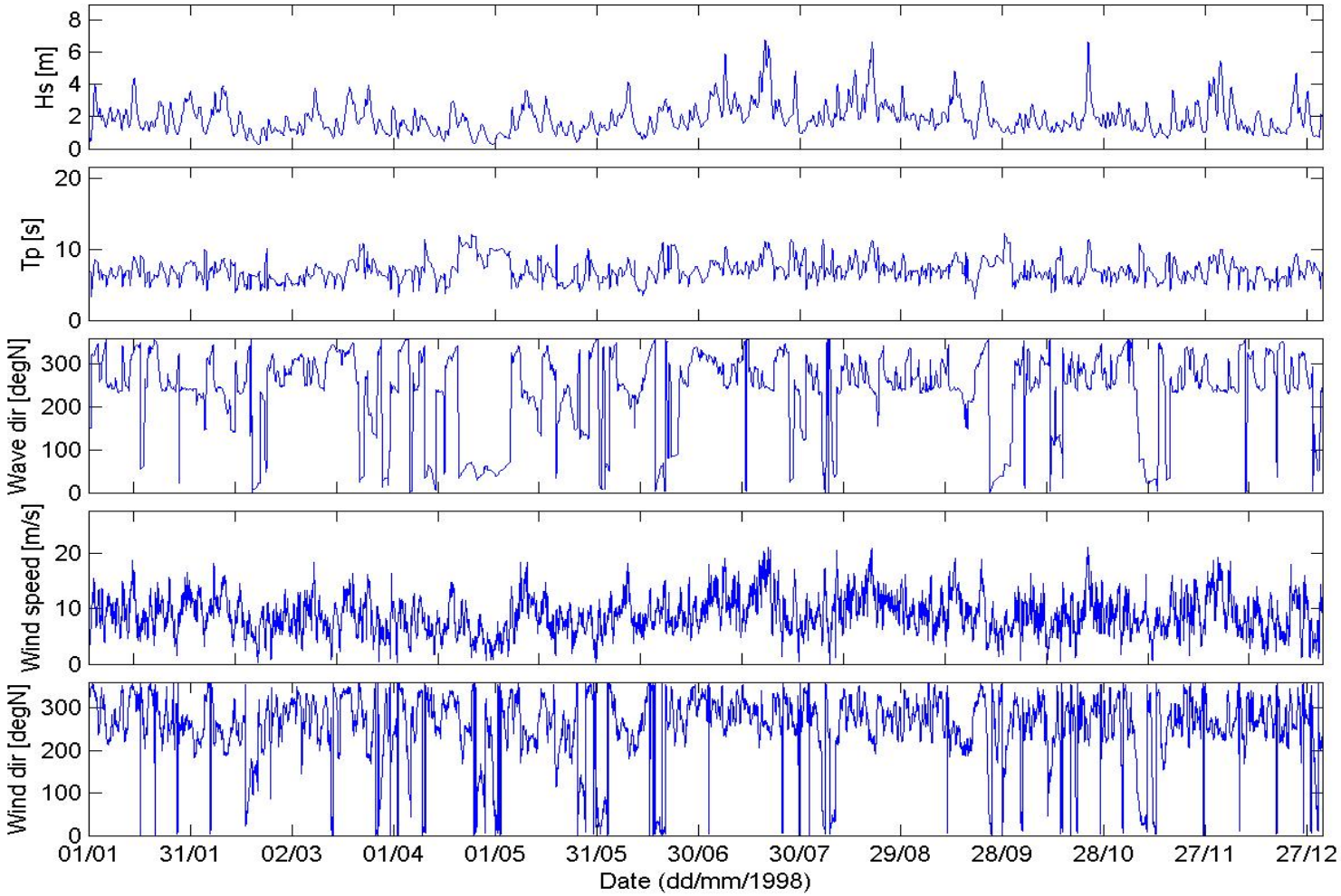

Figure 9.10 Time series plot of waves and winds during 1998.

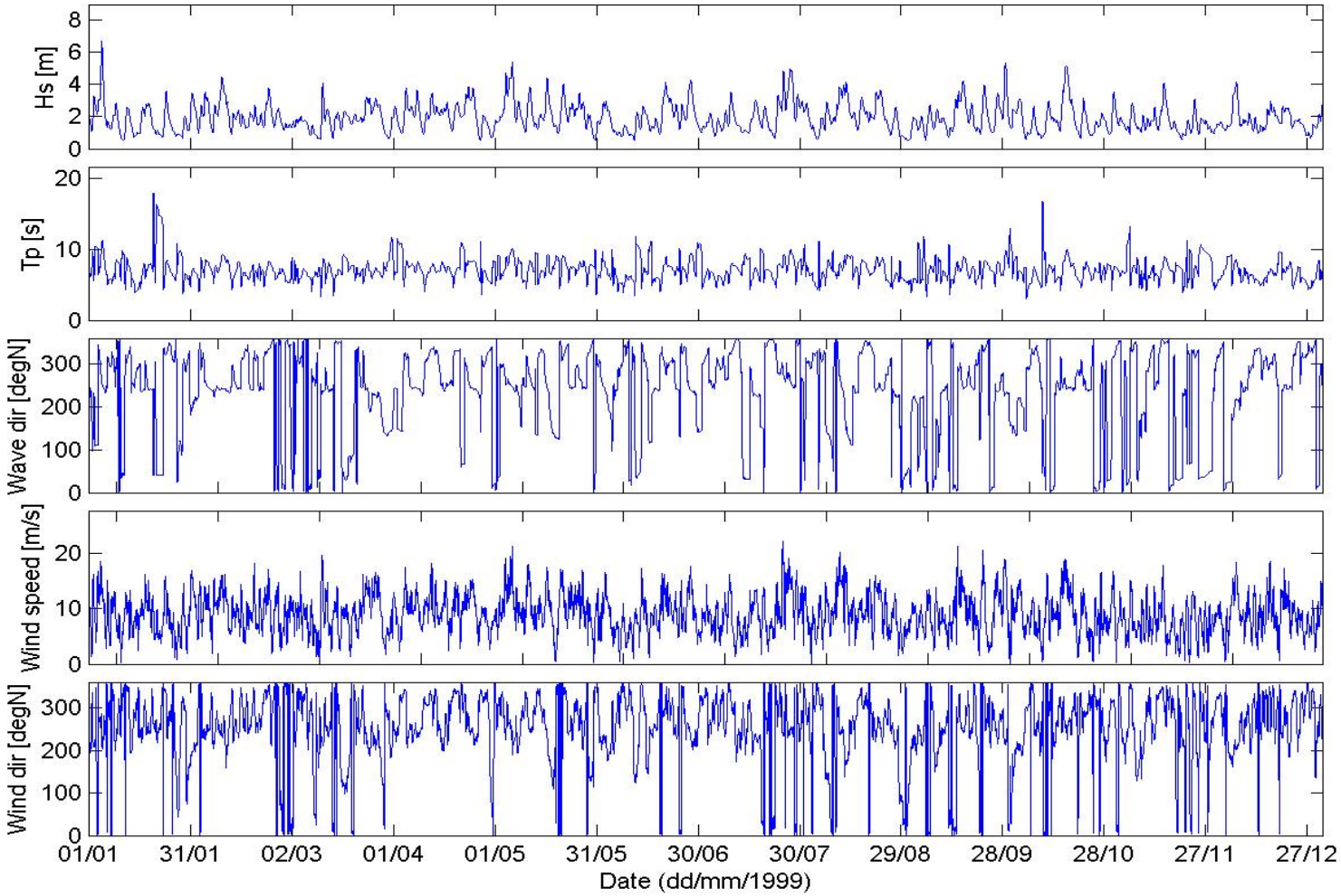

Figure 9.11 Time series plot of waves and winds during 1999.

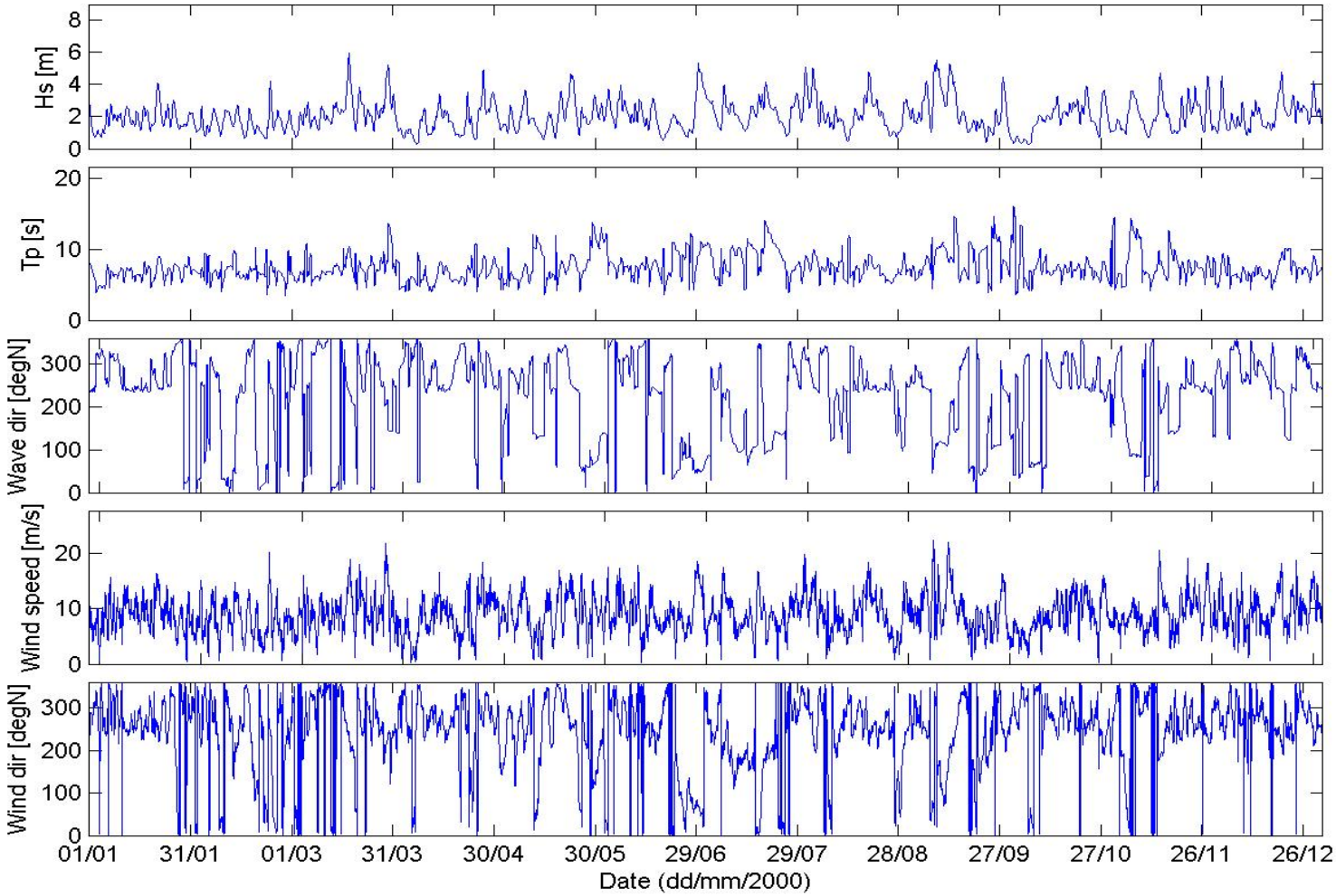

Figure 9.12 Time series plot of waves and winds during 2000.

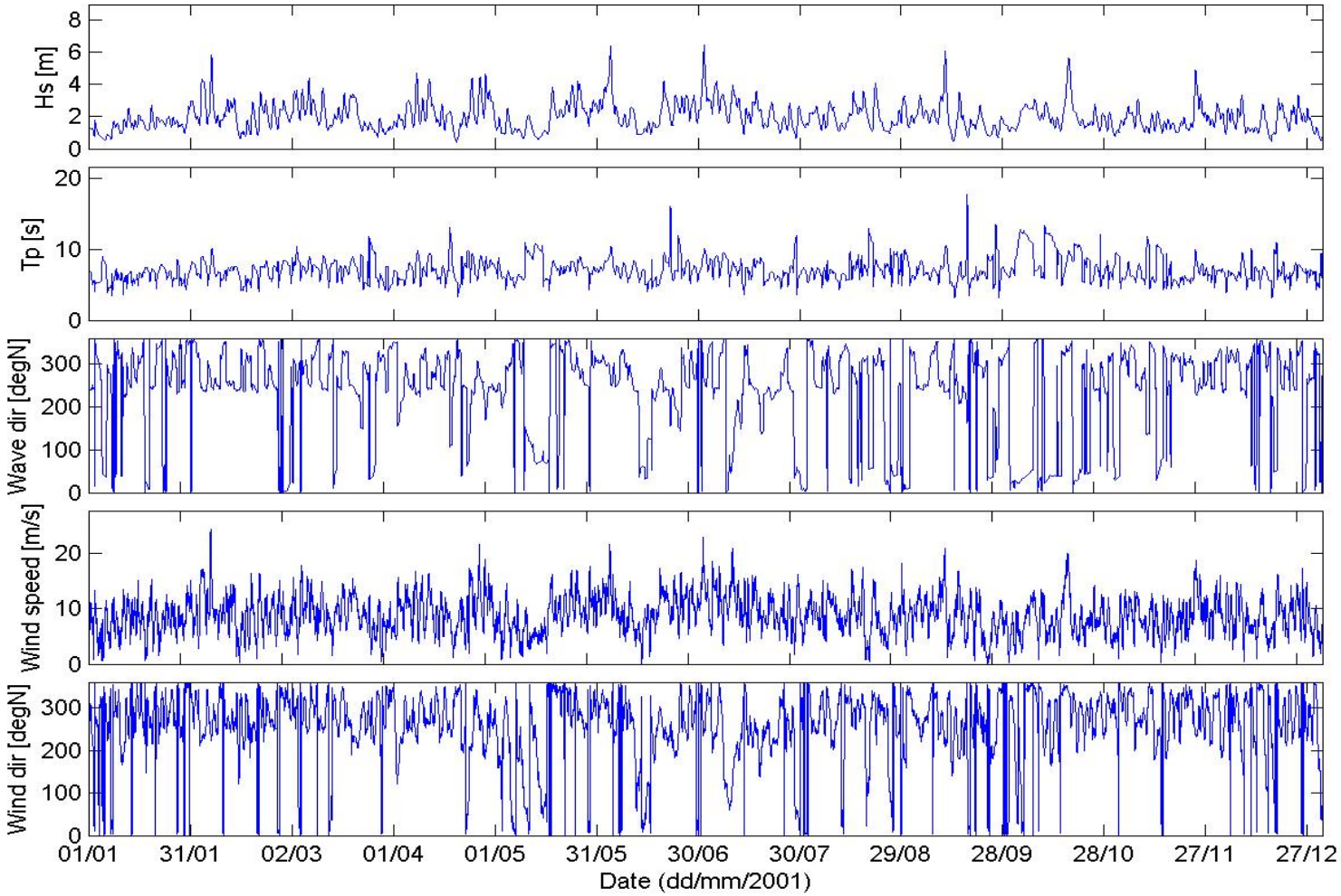

Figure 9.13 Time series plot of waves and winds during 2001.

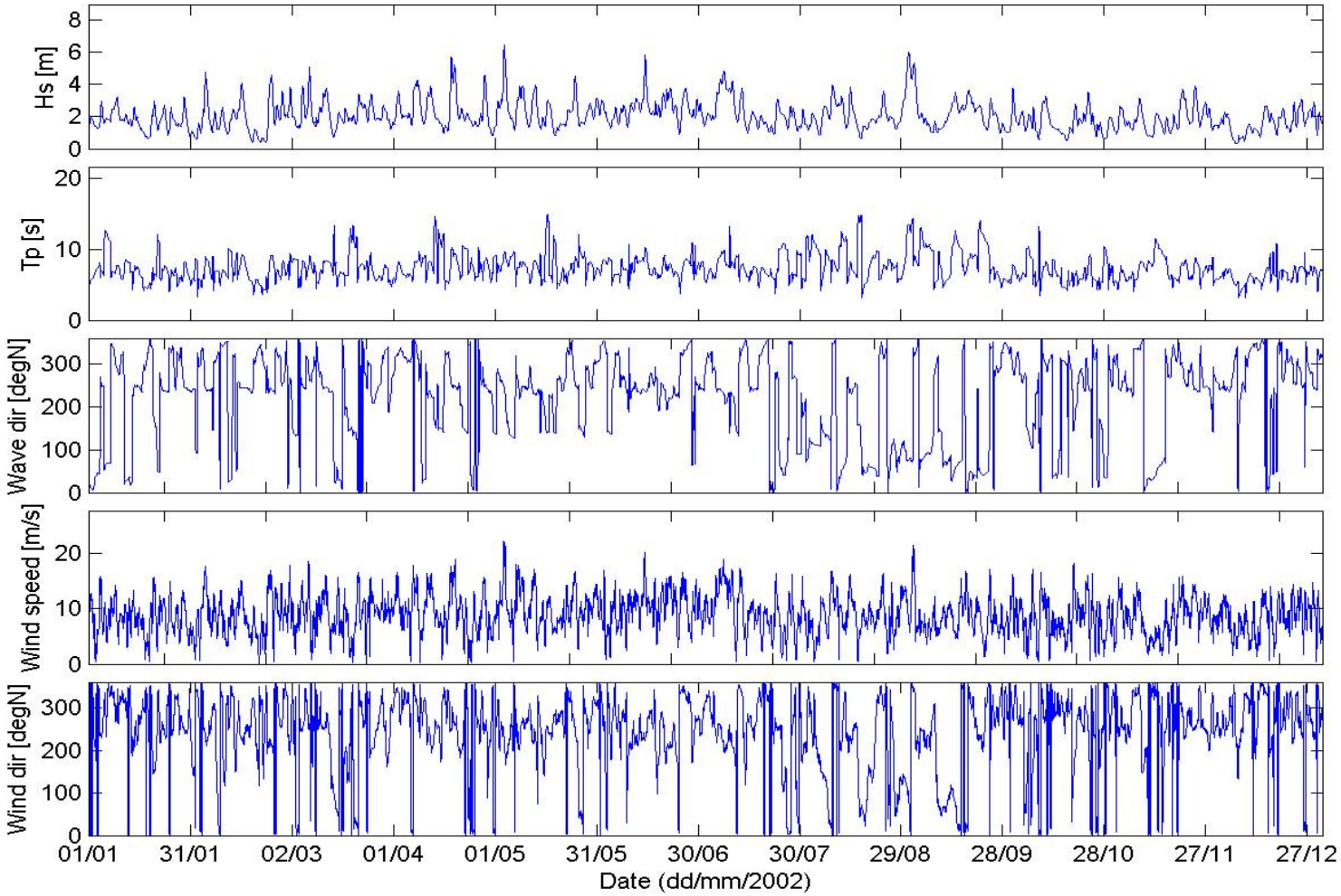

Figure 9.14 Time series plot of waves and winds during 2002.

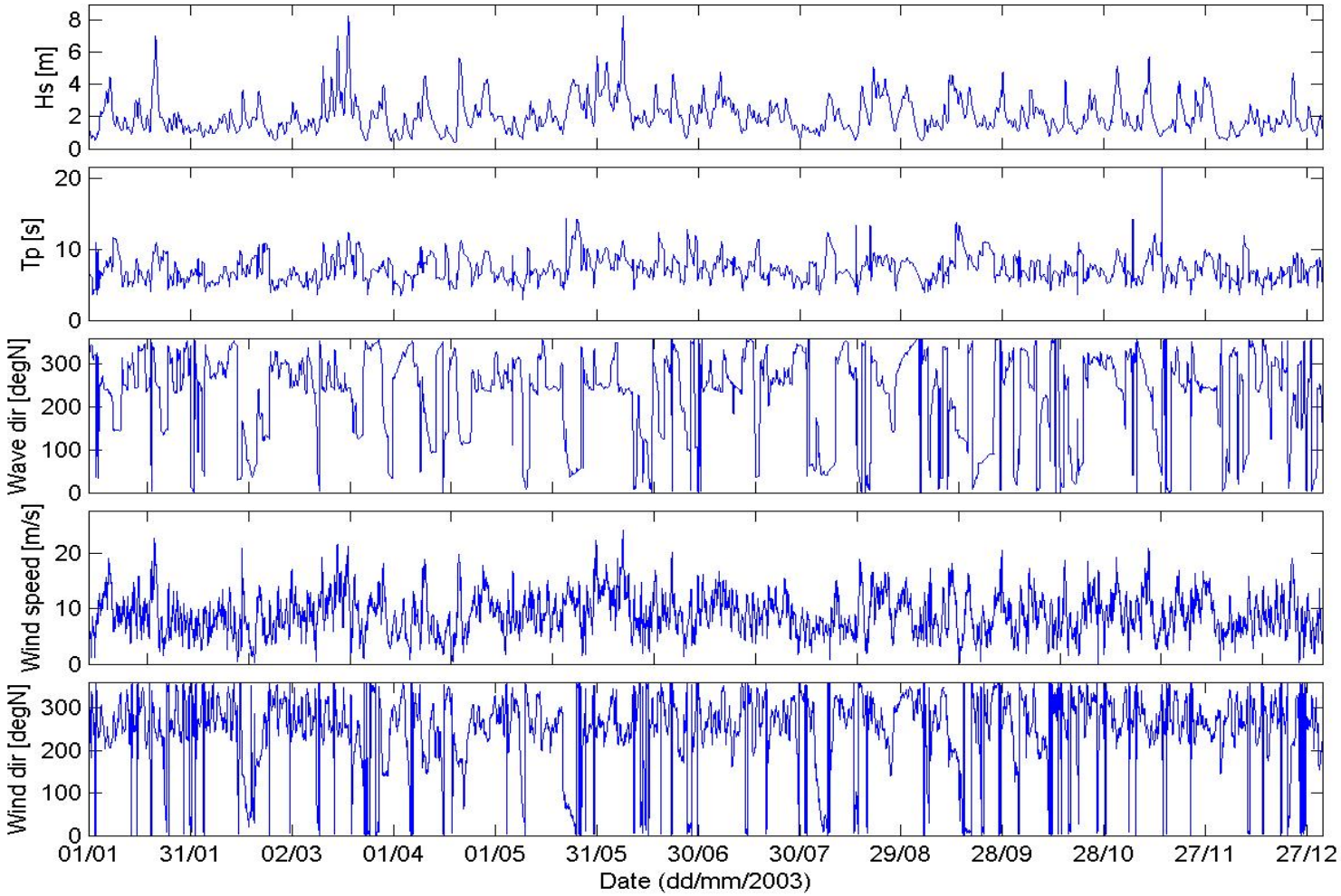

Figure 9.15 Time series plot of waves and winds during 2003.

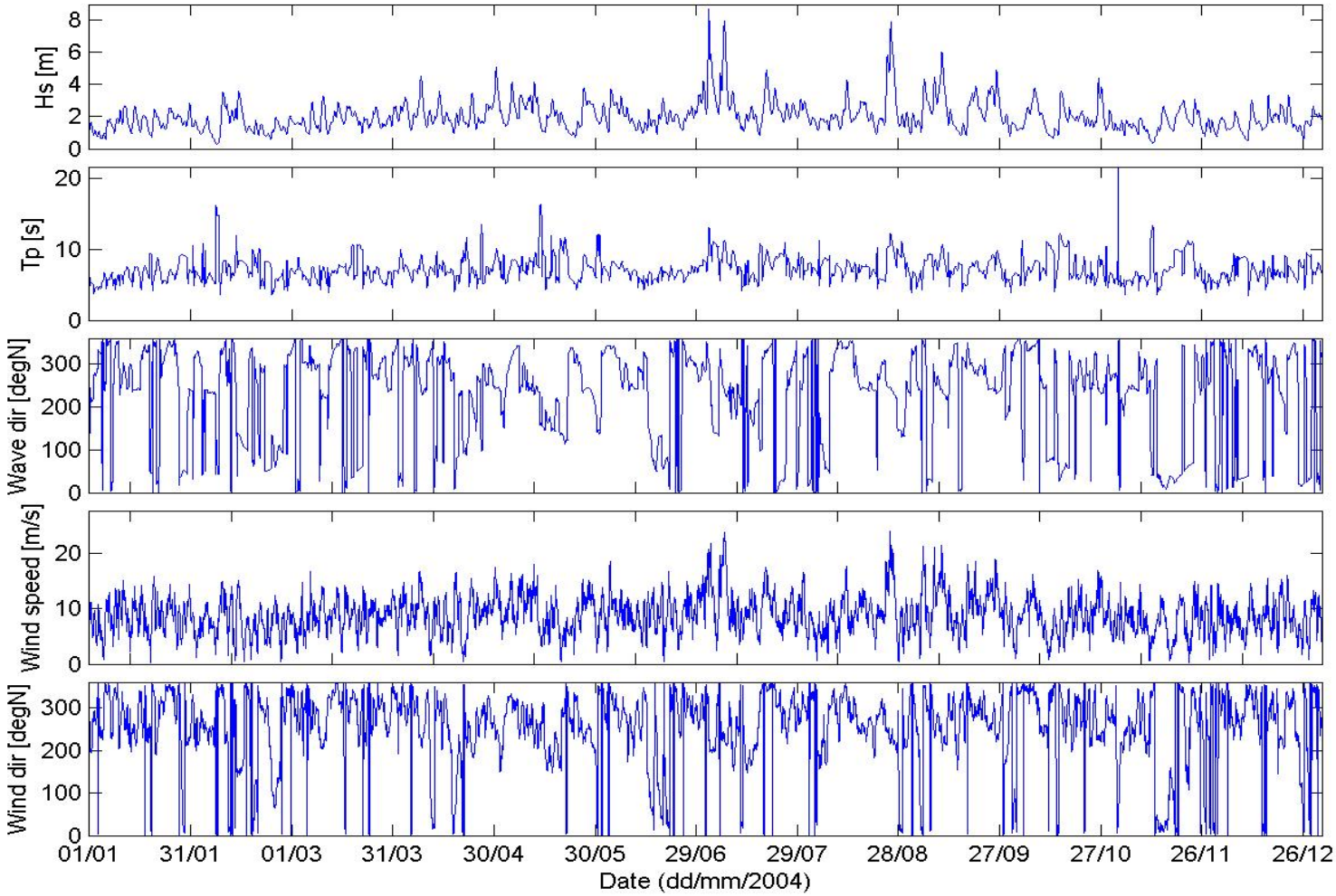

Figure 9.16 Time series plot of waves and winds during 2004.

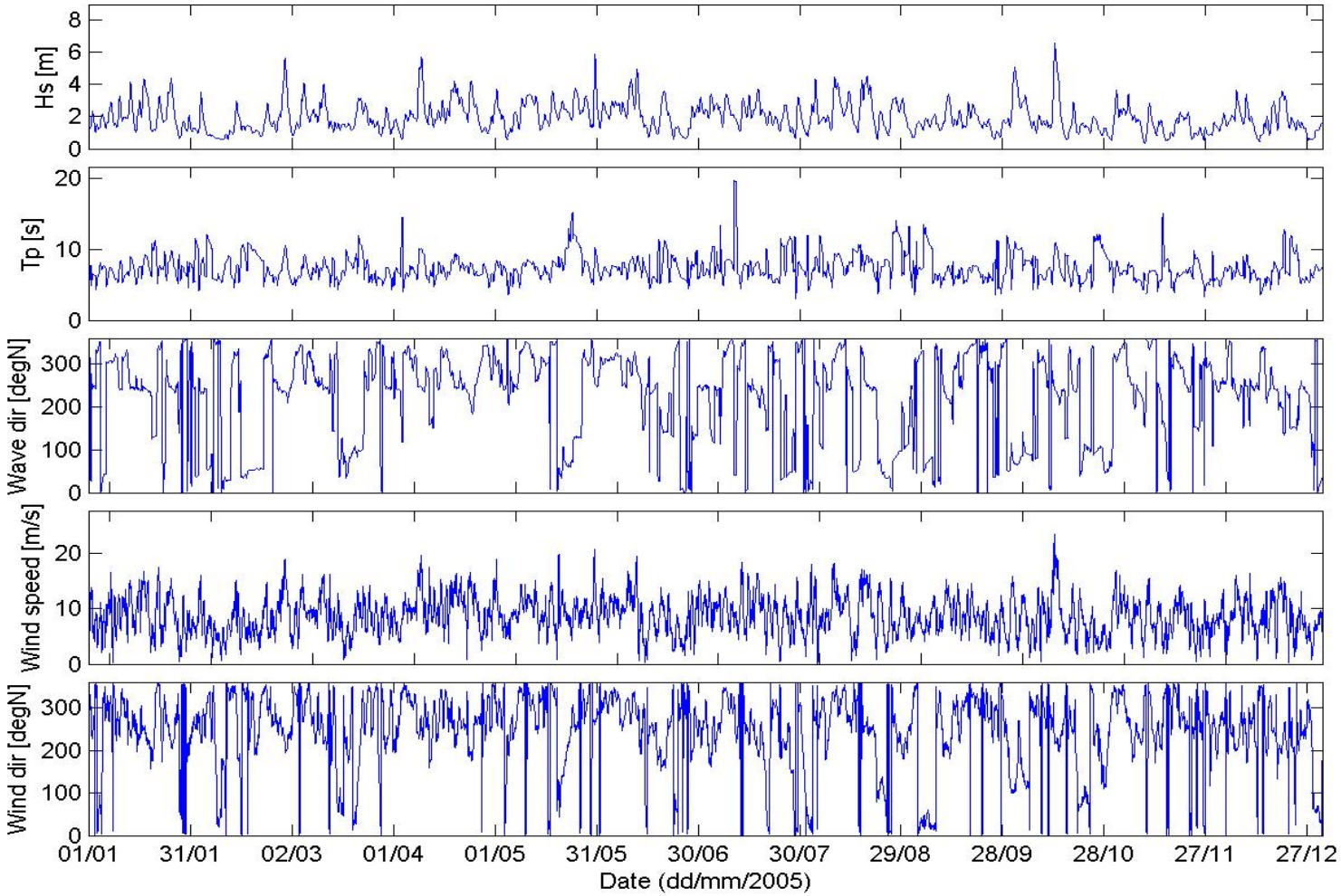

Figure 9.17 Time series plot of waves and winds during 2005.

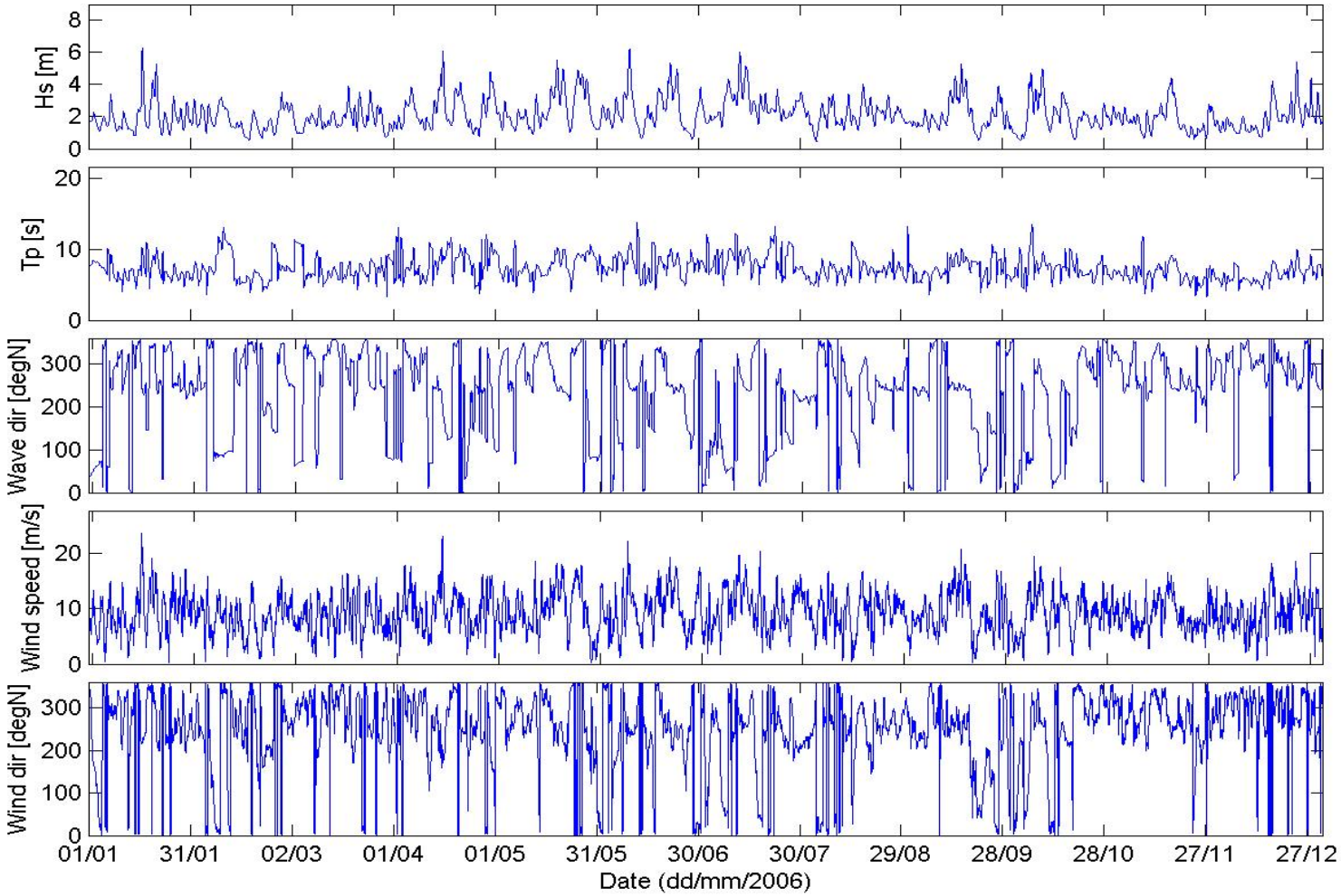

Figure 9.18 Time series plot of waves and winds during 2006.

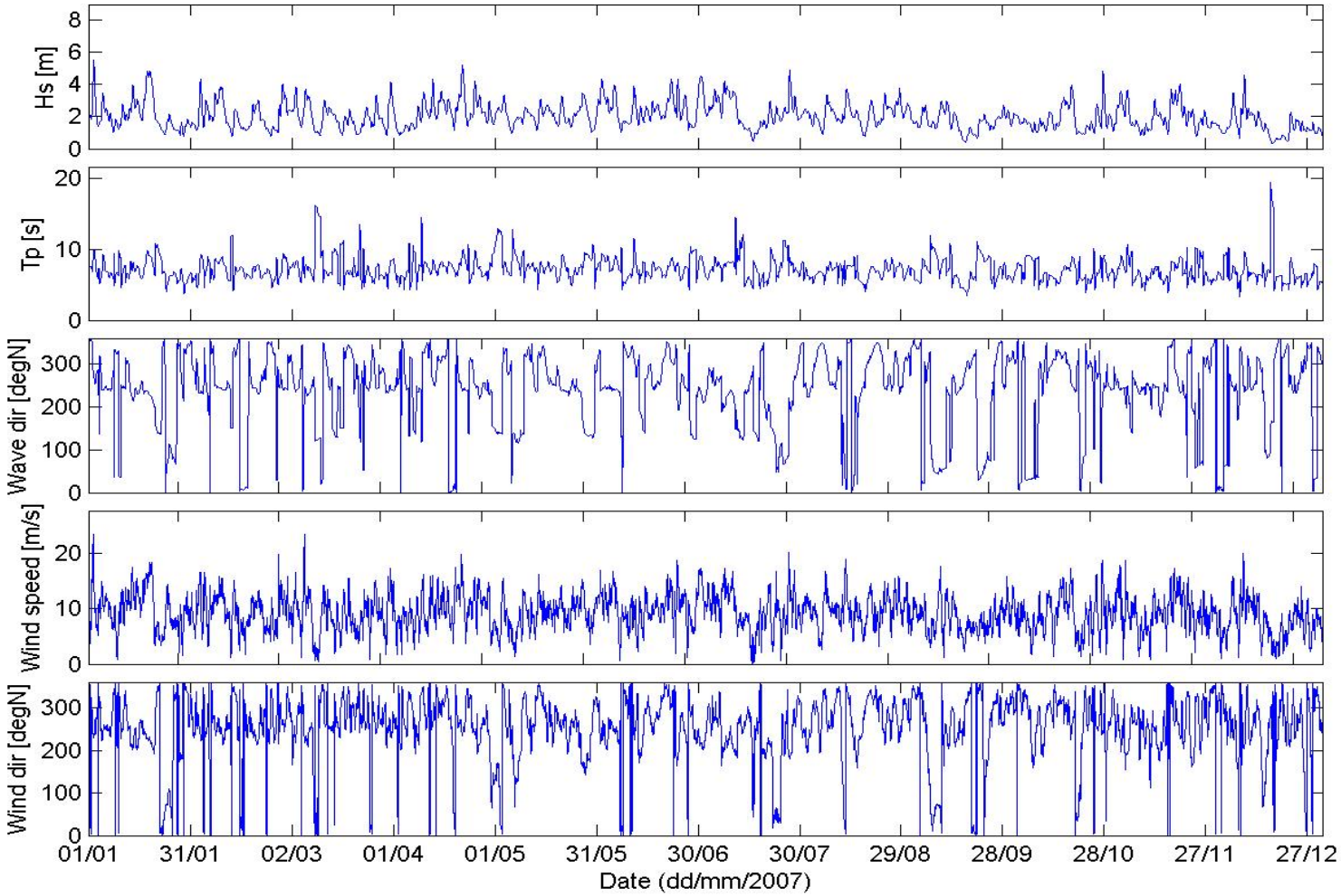

Figure 9.19 Time series plot of waves and winds during 2007.

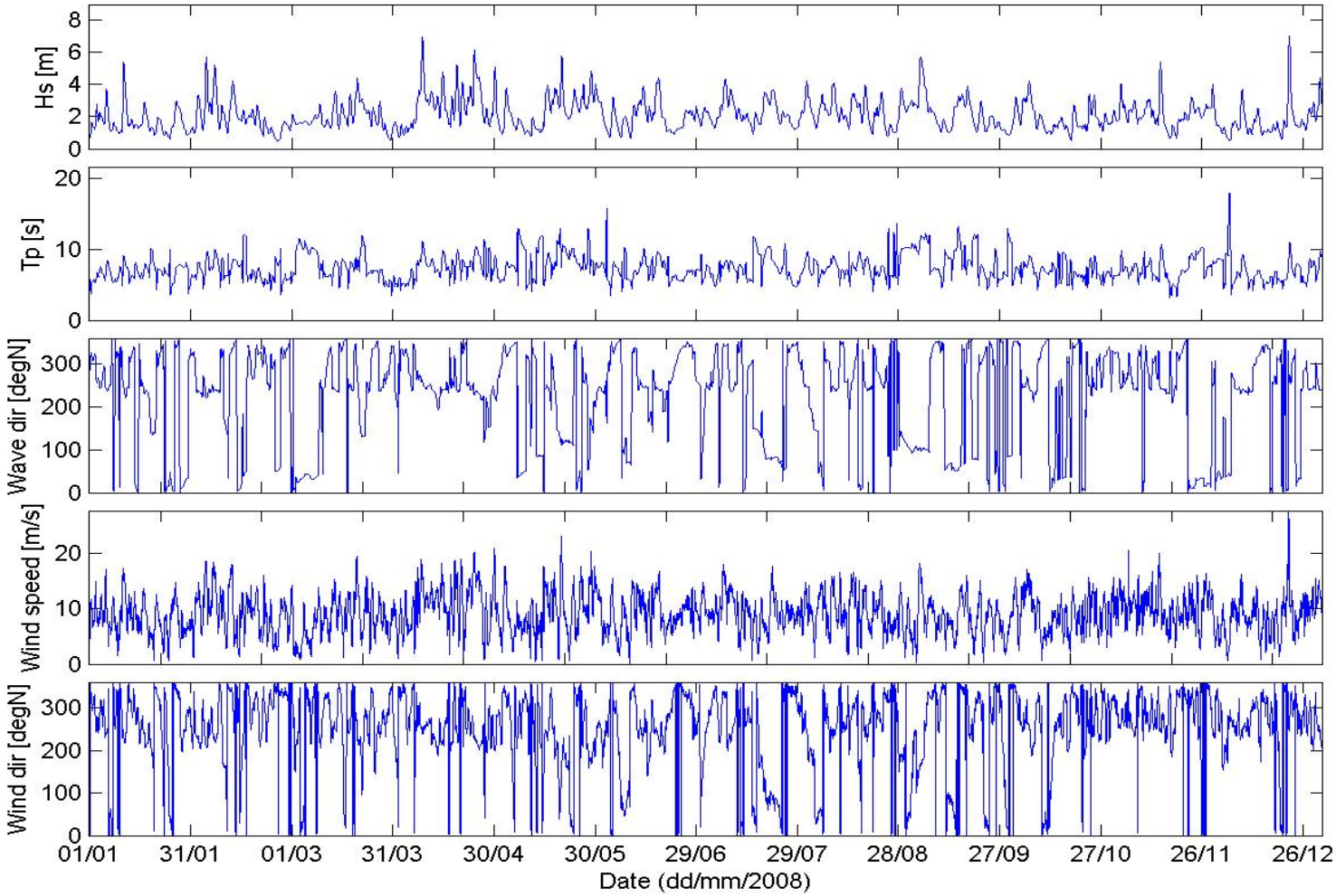

Figure 9.20 Time series plot of waves and winds during 2008.

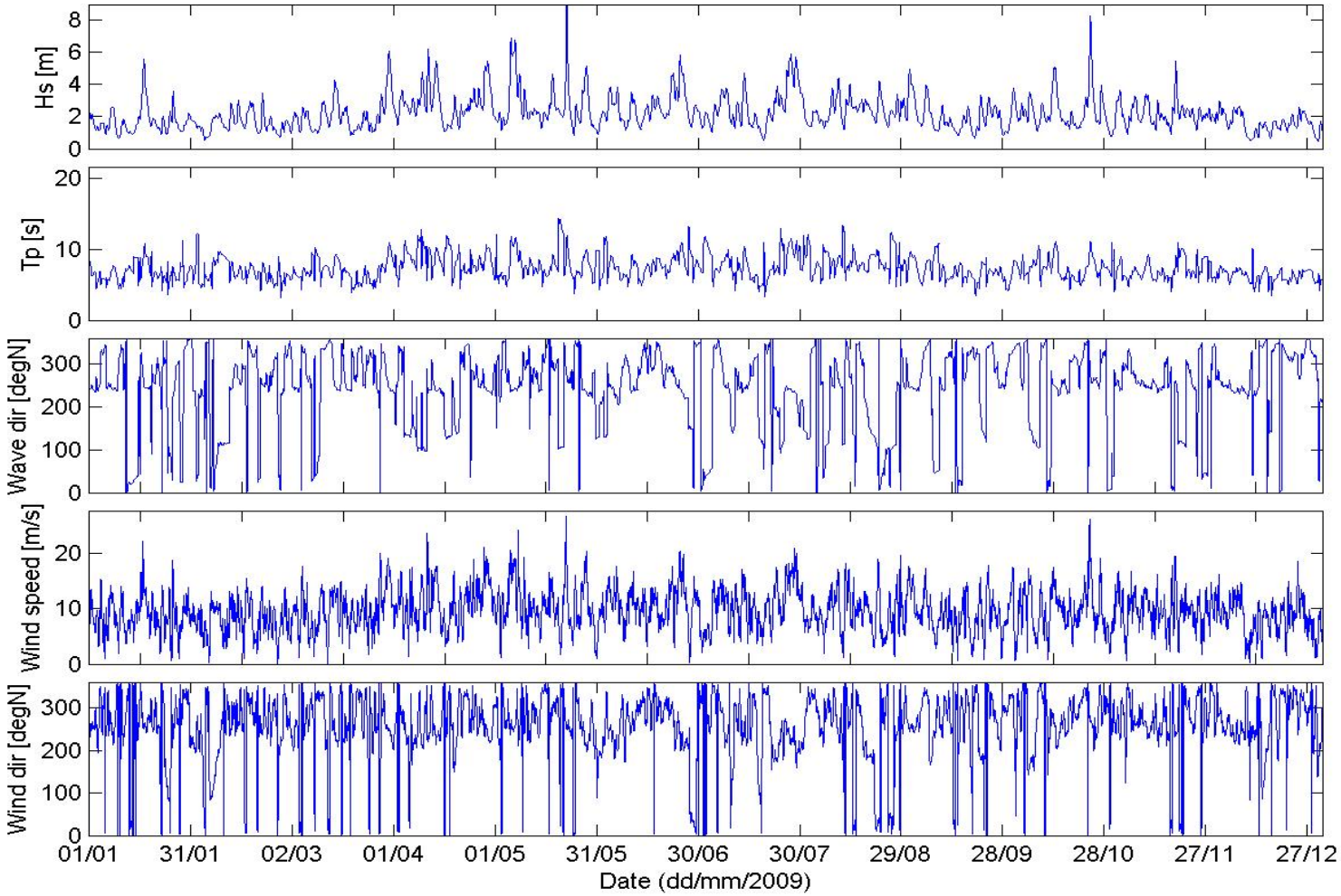

Figure 9.21 Time series plot of waves and winds during 2009.

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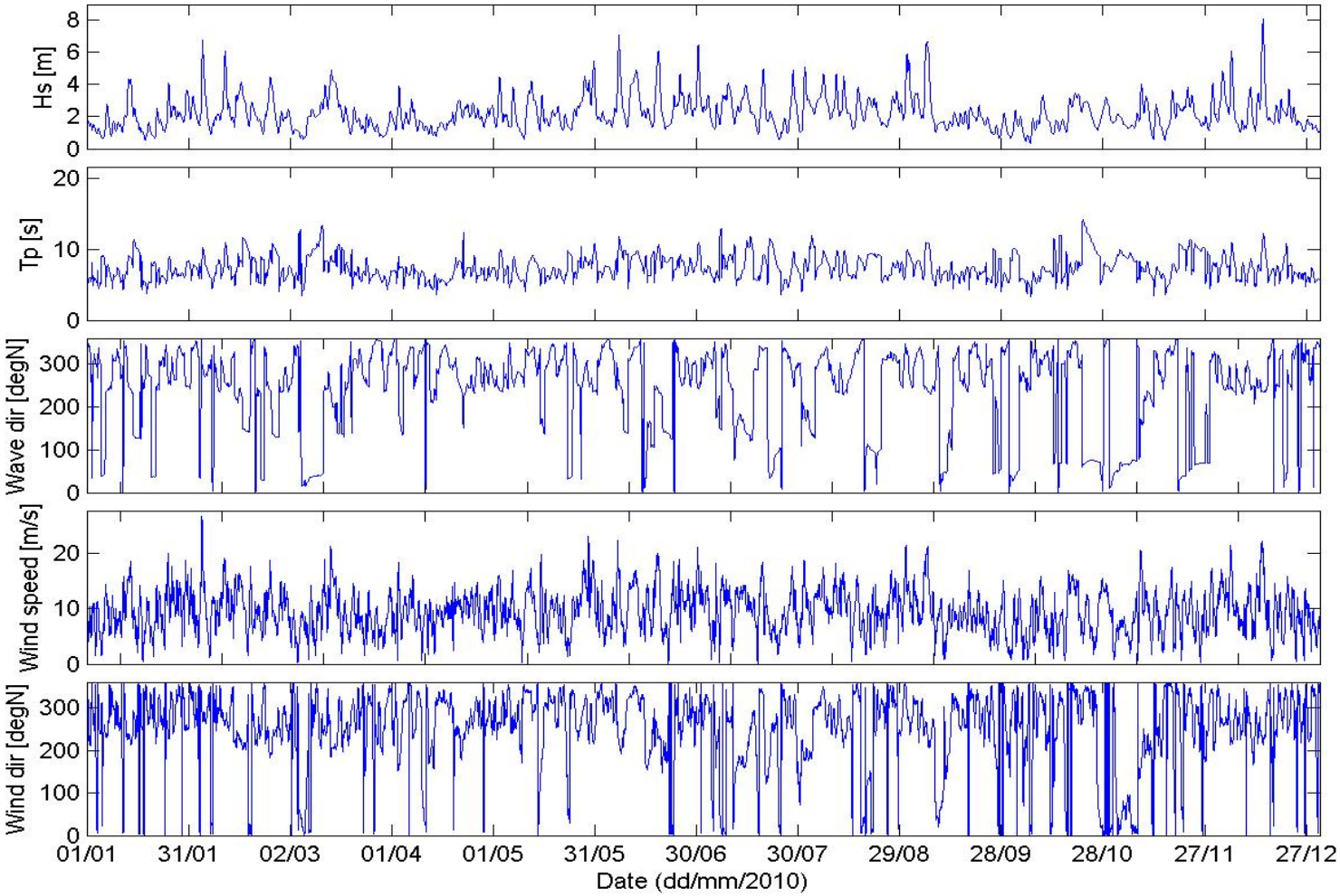

Figure 9.22 Time series plot of waves and winds during 2010.

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